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DEMONSTRATION OF THE AIR FORCE SITE CHARACTERIZATION AND ANALYSIS PENETROMETER SYSTEM (AFSCAPS) AT PATRICK AFB IN SUPPORT OF THE INTRINSIC REMEDIATION (NATURAL ATTENUATION) OPTION

Work performed under
Contract No. F08635-93-C-0080
SETA Subtask 8.01.1

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ARA Report No. 5868-322
May 4, 1994

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INTRODUCTION

The Air Force Civil Engineering Support Agency (AFCESA) retained Applied Research Associates, Inc. (ARA) to demonstrate, test, and evaluate (DT&E) the application of the Air Force Site Characterization and Analysis Penetrometer System (AFSCAPS) in support of the Air Force's intrinsic remediation (natural attenuation) initiatives. One of the key components of the AFSCAPS involves the use of a Nd:YAG dye pumped laser system to induce fluorescence as the CPT probe is advanced into the soils. Laser Induced Fluorescence (LIF) has been shown to be useful in identifying Petroleum, Oil, and Lubricant (POL) contamination.

ARA and their subcontractor, Dakota Technologies, Inc. (DTI), in cooperation with Engineering-Science, Inc. (E-S), the United States Environmental Protection Agency (USEPA) Robert S. Kerr Environmental Research Laboratory (RSKERL), and the CES/CEV office at Patrick Air Force Base jointly conducted an intensive subsurface investigation of soil and groundwater at the ST-29 site located at Patrick Air Force Base (AFB), Florida, and the former fire training area at Kennedy Space Center, Cape Canaveral, Florida. This investigation commenced 21 March 1994 and was completed on 01 April 1994. The three objectives of this investigation were to:

- Demonstrate the CPT's capabilities to quickly locate and define the areal and vertical extent of the liquid-phase plume using LIF, and to rapidly install monitoring points and collect soil samples to provide additional data necessary to define the dissolved-phase plume, and

- Adequately assess the subsurface conditions at the ST29 site to allow E-S to model the potential for natural attenuation using the Bio-Plume II numerical model,

- Provide data collection capabilities to support the United States Environmental Protection Agency's (EPA), efforts aimed at modeling the fate and transport of chlorinated solvents at the former fire training area noted above.

This data report contains a brief description of the site, data obtained and a brief interpretation of the data. Data obtained and a brief interpretation of the data. A more detailed analysis of the LIF and analytical laboratory data will be presented in a later report.

BACKGROUND

CPT Capabilities

Historically, the cone penetrometer has been employed as an expeditious and effective means of analyzing the lithology of a site by measuring the resistance of different soil types against the penetrometer probe as it is advanced into the subsurface. ARA has expanded the CPT's capabilities in several ways to allow further definition of the subsurface environment.

The DTI Nd:YAG laser system was integrated into the CPT by ARA and DTI to locate fuel contamination using the LIF response of the soil/fuel mixture. Subsequently, the LIF response can be correlated to the total petroleum hydrocarbon (TPH) concentration present within the soil. To date, the LIF laser system's primary function has been to define the liquid phase plume.

To aid in defining the dissolved-phase plume, ARA has developed a rapid method of installing small-diameter (0.5-inch) monitoring wells. These wells are typically installed based upon the LIF-CPT data and can be installed to any desired depth with a screened interval typically ranging between 1 to 2 meters. The wells are constructed using 0.5-inch slotted PVC well screen and either 0.5-inch PVC or 0.25-inch OD Teflon® tubing as riser material. Experience has demonstrated that these wells perform well in aquifers where the depth to the potentiometric surface (water table under unconfined conditions) does not exceed the suction capacity of a vacuum pump (typically about 25 feet below grade).

Collection of soil samples serves several purposes. First it provides a physical specimen with which the CPT data can be correlated. In essence, it allows the observer to look at the CPT cone tip and sleeve stresses combined with the pore water pressure data

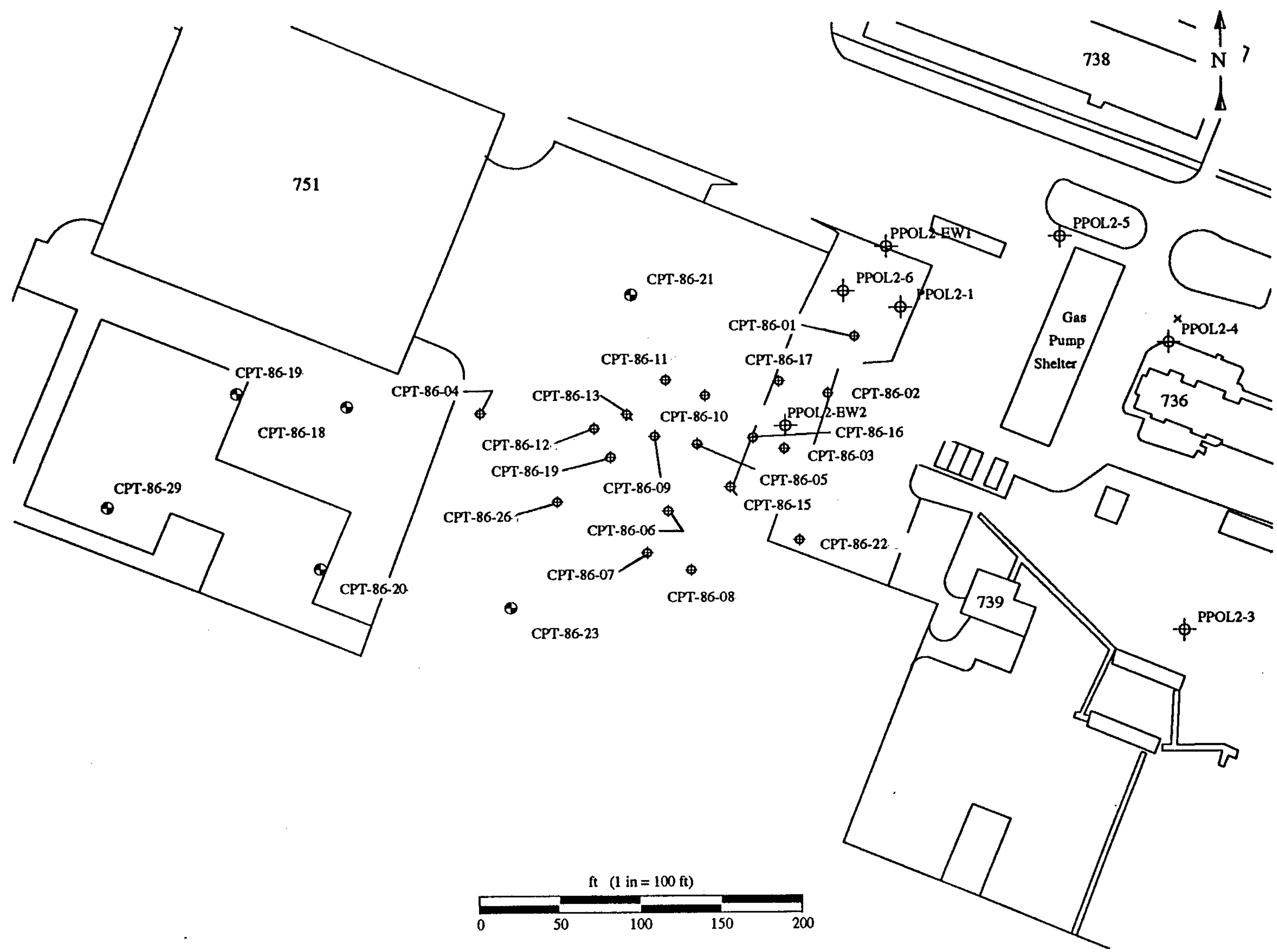
indicated on the CPT logs and compare it directly with the in situ soils. This allows for accurate interpretation of the CPT logs and subsequent interpretation of the overall site lithology. Secondly, subsequent chemical analysis of the soil samples for total petroleum hydrocarbons (TPH) provides a correlation between LIF data and the in situ TPH concentrations. Finally, additional chemical analysis of the soil samples provides data required to both model the natural attenuation potential of the site using the Bioplume II numerical model and develop correlation between the LIF response and the level of soil contamination.

SITE DESCRIPTION

The efforts of this investigation were primarily devoted to the ST-29 site (Figure 1, Site Map) located at Patrick AFB. However, a limited investigation was conducted at the former fire training area located at the Kennedy Space Center, Cape Canaveral, Florida. The following sections pertain to the ST-29 site describing the site geology, hydrogeology, and soil and groundwater quality. This information was extracted from the work plan prepared by Engineering-Science, Inc. (Ref. 1) for this site. Only limited background information pertaining to the fire training area was available at this time.

Site Geology and Hydrogeology

Patrick AFB and Cape Canaveral Air Force Station (AFS) are situated on undifferentiated marine sands and the Pleistocene-age Anastasia and Caloosahatchee Marl Formations; these three units comprise the surficial unconsolidated deposits in the area. The Anastasia Formation is a discontinuous layer of undifferentiated sands with silt and shells. Acting as a semi-continuous confining unit at a depth of approximately 50 feet, the Caloosahatchee Marl Formation consists of calcareous, sandy clay deposits. Above the semi-confining layer, the surficial deposits form a shallow, unconfined aquifer. Underlying the Caloosahatchee Formation is the Tamiami Formation, which is made up of limestones, marls, silty sands, and clay. The Tamiami Formation forms a shallow bedrock aquifer. The marine sands, clays, and limestones of the Hawthorn Formation underlie the Tamiami



APPLIED RESEARCH ASSOCIATES, INC.

FIGURE 1: Site Map, Patrick AFB, FL

Formation. Interspersed limestone layers form localized aquifers within the Hawthorn Formation. Beneath the Hawthorn Formation is the Floridan Aquifer, which is comprised of Ocala Limestone and extends to a depth of over 1,500 feet below msl.

The surface geology at Site ST-29 consists of fine- to coarse-grained sand which is poorly to moderately sorted and contains up to 40 percent shell fragments (Ref. 2). The marine sand deposits of the top 25 feet at the site are of Holocene and Pleistocene age. These sand deposits contain interspersed organics with dark gray and black discolorations from petroleum constituents. Soil boring samples exhibited organic vapor readings ranging from background levels to greater than 200 ppmv. The Anastasia Formation is discontinuous in this area and therefore was not found in some areas of Site ST-29. The Caloosahatchee Marl formation was reported to be encountered between the depths of 25 and 51 feet below grade (Ref. 2). This soil layer is blue and gray in color, with dense, moderately well-sorted, very fine- to medium-grained silty sand with 5 to 65 percent shell fragments. Organic constituents were detected throughout the deposit and were prevalent in distinct thin beds about 0.25 foot thick. No soil discoloration or organic vapor readings above background were noted in these soils. A deposit of clay marl was encountered from 51 feet below grade to at least 57 feet below grade. This layer is typified by blue-gray to dark green soil with shell and limestone fragments, and correlates with the semi-confining, discontinuous layer of sand and silt deposits that occur within the Caloosahatchee Marl.

The shallow groundwater at Site ST-29 resides in an unconfined aquifer at depths of 3.5 to 4.5 feet below grade. The hydraulic gradient at the site ranges from 0.00096 to 0.003 foot per foot (ft/ft) (Ref. 2; Ref. 3). No slug test data are available for the site. An estimated average hydraulic conductivity of 0.26 foot per minute was obtained from data gathered in other areas of Patrick AFB. It was assumed that the soil lithologies throughout Patrick AFB are relatively similar (Ref. 2). Groundwater at the site may be subject to alternating directions of flow toward the Banana River or towards the Atlantic Ocean. This groundwater anomaly is probably related to the operation of locks and dams southwest of the base that are used to control the water levels in the Banana River relative to the Atlantic Ocean. The likelihood of contamination of the deep aquifer from sources in the shallow aquifer is assumed to be minimal because the deep aquifer has sufficient pressure head to

cause the potentiometric surface for the deep aquifer to be greater than that for the water table within the shallow unconfined aquifer (Ref. 2).

Patrick AFB receives its water from the City of Cocoa Beach, Florida, which is supplied by in-land well fields screened in the Floridan aquifer in East Orange County, Florida. A backup water supply for Patrick AFB is supplied by the City of Melbourne, Florida. Patrick AFB maintains five standby potable water supply wells primarily for fire suppression use. These wells are screened in Ocala Formation limestones that host the confined Floridan Aquifer (Ref. 6). Groundwater in the surficial aquifer beneath Site ST-29 is classified as G-II based on the FAC regulations, Chapter 3 [designated as potable if less than 10,000 milligrams per liter (mg/L) of total dissolved solids is present].

Soil Quality

Contaminant sources at Site ST-29 include the five abandoned 5,000-gallon MOGAS USTs northeast of the BX Service Station (Building 736) and the area surrounding the four operational 10,000-gallon MOGAS USTs, situated southeast of the service station. Site characterization data from the Phase II (stage 1) investigation detected organic vapor levels that exceeded 50 ppmv in soil borings SB-1, SB-2, SB-3, SB-5, and SB-6 (SB-1 recorded at 200 ppmv; SB-2 recorded 170 ppmv) (Ref. 4). Organic vapors levels in other samples from the remaining soil borings and from the monitoring well borings were relatively low (2 to 13 ppmv). Most soil samples exhibited peculiar odors described variously by the on-site geologist as petroleum (most samples), alcohol, diesel, old gasoline, sulfur, and organic matter. No soil or groundwater samples were submitted for laboratory analyses during the stage 1 investigation because the site had not been included in the IRP until stage 2 testing.

The collection and analysis of soil samples from eight boreholes completed during the Phase II (stage 2) round 2 sampling event indicated a high level of petroleum hydrocarbons at sample location SB-2 on the west side of the car wash. Xylenes were found in SB-1, SB-2, SB-3, and SB-8, with values ranging from 22.3 milligrams per kilogram (mg/kg) in SB-1 to 822 mg/kg-dry in SB-2. Ethylbenzene and toluene were detected in boreholes SB-2, SB-3, and SB-8, with the high value of ethylbenzene and toluene being 100 mg/kg-dry and 38

mg/kg-dry, respectively, in SB-8. An additional contaminant source of potential concern is an unlocated, abandoned UST located somewhere north and/or east of the existing BX Service Station. An attempt by ESE to locate this tank with an electromagnetic survey was unsuccessful. Based on analysis of samples from a deep well located downgradient of the site, soil and groundwater contamination had not occurred at depth at the time of the study.

None of the data obtained from Phase II (stage 2) testing can be used to fully characterize the lateral or vertical extent of contamination. The soil borehole reports (Ref. 4) and soil gas studies (Ref. 5) during soil headspace analysis indicate the area of highest identified soil contamination is near the car wash. This suggests that fuel may be migrating from the vicinity of the MOGAS USTs located northeast of the car wash building, or that the area was impacted by a surface fuel spill. A bioventing unit installed in a 20-foot vapor extraction trench along the northeast side of the car wash is currently in operation at the site. During installation of the bioventing unit, soil was visually saturated with hydrocarbon contamination. Bioventing operations are expected to reduce these soil contamination levels near the car wash.

Groundwater Quality and Chemistry

Groundwater was sampled at Site ST-29 during Phase II, (stage 2) site characterizations (Ref. 2). Volatile compounds and chlorinated compounds were detected at low concentration in all six wells. Wells PPOL2-1, PPOL2-2, and PPOL2-4 contained the highest concentration of contaminants. All these wells are located downgradient of either the abandoned USTs northeast of the service station building or downgradient of the operational USTs on the southwest side of the BX service station. Although the contaminant levels detected in groundwater are low, the existing groundwater monitoring wells may not be situated properly to allow detection of all groundwater contamination, especially in the vicinity of the car wash. The extensive soil contamination in the area surrounding the car wash suggests that groundwater contamination may be greater than previously indicated. The soils at the site are highly permeable, unconsolidated sands with shell fragments and minor amounts of clay and organic matter. Therefore, a contaminant plume may be migrating away from the car wash, under the tarmac to the west.

RESULTS

During the course of the Patrick AFB investigation, ARA completed a total of eighteen (18) LIF-CPT soundings. Figure 1 depicts the locations of these soundings. Based upon this data 40 successful 0.5-inch monitoring wells were installed to various depths to allow collection of groundwater samples for subsequent chemical analyses. In addition, 19 soil samples were obtained to provide additional data required for the Bioplume II modeling and to allow correlation with both the CPT and LIF profiles. A summary of the soundings completed and the respective well completion details and soil sampling intervals at this site is included in Table 1.

A total of 11 LIF-CPT soundings were completed at the former fire training area located at the Kennedy Space Center, Cape Canaveral. Interpretation of this data allowed effective placement of 11 monitoring wells and collection of eight soil samples. A site map of this site with these LIF-CPT locations is currently being obtained from O'Brien & Gere Engineers, Inc.. It will be included in the final analytical report. A summary of soundings completed and respective well completion details and soil sampling intervals is included in Table 2.

Interpretation of CPT Profiles

Inspection of the CPT profiles indicate that the overburden soils at the ST-29 site consist of various gradations of sands with occasional discontinuous seams of silty clays and clay. This interpretation is in good agreement with findings from previous investigations (Ref. 1). The basis for this interpretation is presented below.

Comparison of tip stress, friction ratio and penetration pore pressure profiles are the most important parameters for estimating soil type and stratigraphy from CPT data. The magnitude of the tip resistance is a function of the strength of the soil, with stronger materials having higher tip resistances. Tip resistance also increases as the coarse grained soil content increases, and decreases as the fine grained content increases. The degree of

Table 1
Summary of CPT Soundings
ST-29 Site
Patrick AFB, Florida

Test Id	Date	Type	MW Type	Start Depth	Max Depth
CPT-86-01-LIF	21-Mar-94	CPT-LIF			19.41
CPT-86-01-MW	21-Mar-94	MW	Risers		8.30
CPT-86-02-LIF	21-Mar-94	CPT-LIF			16.06
CPT-86-02-MW	21-Mar-94	MW	Tubing		8.14
CPT-86-02-MW	21-Mar-94	MW	Risers		13.91
CPT-86-02-SS01	24-Mar-94	SS		3.50	4.00
CPT-86-02-SS02	24-Mar-94	SS		4.00	4.45
CPT-86-02-SS03	24-Mar-94	SS		4.45	5.00
CPT-86-02-SS04	24-Mar-94	SS		5.50	6.00
CPT-86-02-SS05	24-Mar-94	SS		6.20	6.80
CPT-86-02-SS06	24-Mar-94	SS		6.80	7.00
CPT-86-03-LIF	21-Mar-94	CPT-LIF			19.29
CPT-86-03-MW01	21-Mar-94	MW	Risers		19.54
CPT-86-03-MW02	21-Mar-94	MW	Tubing		14.08
CPT-86-03-MW03	21-Mar-94	MW	Risers		8.31
CPT-86-03-SS01	24-Mar-94	SS		3.33	3.92
CPT-86-03-SS02	24-Mar-94	SS		4.17	4.75
CPT-86-03-SS03	24-Mar-94	SS		4.83	5.33
CPT-86-03-SS04	24-Mar-94	SS		5.33	5.83
CPT-86-04-LIF	21-Mar-94	CPT-LIF			17.03
CPT-86-04-MW	21-Mar-94	MW	Risers		10.00
CPT-86-04-MW02	24-Mar-94	MW	Riser		12.13
CPT-86-05-LIF	22-Mar-94	CPT-LIF			19.30
CPT-86-05-MW01	22-Mar-94	MW	Risers		20.02
CPT-86-05-MW02	24-Mar-94	MW	Riser		8.05
CPT-86-05B-LIF	22-Mar-94	CPT-LIF			19.73
CPT-86-06-LIF	22-Mar-94	CPT-LIF			16.09
CPT-86-06-MW01	22-Mar-94	MW	Riser		8.01
CPT-86-07-LIF	22-Mar-94	CPT-LIF			16.00
CPT-86-07-MW01	22-Mar-94	MW	Riser		8.00
CPT-86-08-LIF	22-Mar-94	CPT-LIF			19.51
CPT-86-08-MW01	22-Mar-94	MW	Tubing		8.01
CPT-86-09-LIF	22-Mar-94	CPT-LIF			19.35
CPT-86-09-MW01	22-Mar-94	MW	Risers		8.06
CPT-86-09-MW01	24-Mar-94	MW	Riser		8.00
CPT-86-09-MW02	24-Mar-94	MW	Tube		15.00
CPT-86-09-SS01	24-Mar-94	SS		2.50	4.5
CPT-86-09-SS02	24-Mar-94	SS		4.50	6.5
CPT-86-10-LIF	22-Mar-94	CPT-LIF			19.48
CPT-86-10-MW01	22-Mar-94	MW	Risers		8.00
CPT-86-11-LIF	23-Mar-94	CPT-LIF			15.72
CPT-86-11-MW01	23-Mar-94	MW	Tube		8.00
CPT-86-12-LIF	23-Mar-94	CPT-LIF			15.99
CPT-86-12-MW01	23-Mar-94	MW	Tube		16.02
CPT-86-12-MW01	24-Mar-94	MW	Riser		8.07
CPT-86-12B-LIF	23-Mar-94	CPT-LIF			15.71
CPT-86-13-LIF	23-Mar-94	CPT-LIF			17.47

Table 1
Summary of CPT Soundings
ST-29 Site
Patrick AFB, Florida

Test Id	Date	Type	MW Type	Start Depth	Max Depth
CPT-86-13-MW01	23-Mar-94	MW	Tube		17.49
CPT-86-13-SS01	24-Mar-94	SS		4.50	6.50
CPT-86-14-LIF	23-Mar-94	CPT-LIF			16.71
CPT-86-14-MW01	23-Mar-94	MW	Tube		16.73
CPT-86-15-LIF	23-Mar-94	CPT-LIF			19.39
CPT-86-16-LIF	23-Mar-94	CPT-LIF			19.50
CPT-86-16-MW01	23-Mar-94	MW	Riser		8.01
CPT-86-16-SS01	24-Mar-94	SS		3.00	5.35
CPT-86-16-SS02	24-Mar-94	SS		5.35	7.7
CPT-86-17-LIF	23-Mar-94	CPT-LIF			14.60
CPT-86-18-MW01	23-Mar-94	MW			3.16
CPT-86-18-MW01	23-Mar-94	MW	Tube		16.00
CPT-86-18-MW02	23-Mar-94	MW	Riser		8.00
CPT-86-19-MW01	23-Mar-94	MW	Tube		16.00
CPT-86-19-MW02	23-Mar-94	MW	Riser		8.00
CPT-86-20-MW01	23-Mar-94	MW	Tube		16.07
CPT-86-20-MW02	23-Mar-94	MW	Riser		8.00
CPT-86-21-MW01	24-Mar-94	MW	Riser		8.00
CPT-86-21-MW02	24-Mar-94	MW	Tube		15.30
CPT-86-21-MW03	24-Mar-94	MW	Riser		8.05
CPT-86-22-LIF	24-Mar-94	CPT-LIF			14.81
CPT-86-22-MW01	24-Mar-94	MW	Riser		13.46
CPT-86-22-MW02	24-Mar-94	MW	Riser		8.06
CPT-86-23-MW01	25-Mar-94	MW	Riser		7.01
CPT-86-23-MW02	25-Mar-94	MW	Riser		13.50
CPT-86-24-MW01	25-Mar-94	MW	Riser		6.50
CPT-86-24-MW02	25-Mar-94	MW	Riser		13.00
CPT-86-25-MW01	25-Mar-94	MW	Riser		6.50
CPT-86-25-MW02	25-Mar-94	MW	Riser		13.00
CPT-86-26-MW01	25-Mar-94	MW	Riser		7.00
CPT-86-26-MW02	25-Mar-94	MW	Riser		13.50

Table 2
Summary of CPT Soundings
Former Fire Training Area
Kennedy Space Center
Cape Canaveral, Florida

Test ID	Date	Type	MW type	Start Depth	Max Depth
CCAFB-01	29-Mar-98	CPT-LIF			14.31
CCAFB-01-SS01	30-Mar-98	SS		5.50	7.5
CCAFB-01-SS02	30-Mar-98	SS		7.50	9.5
CCAFB-01B-SS01	30-Mar-98	SS		5.50	7.5
CCAFB-01B-SS02	30-Mar-98	SS		7.50	9.5
CCAFB-02	29-Mar-98	CPT-LIF			10.12
CCAFB-03	29-Mar-98	CPT-LIF			15.30
CCAFB-04	29-Mar-98	CPT-LIF			13.23
CCAFB-05	29-Mar-98	CPT-LIF			15.01
CCAFB-06	29-Mar-98	CPT-LIF			15.81
CCAFB-06-SS01	30-Mar-98	SS		3.50	5.5
CCAFB-06-SS02	30-Mar-98	SS		5.50	7.5
CCAFB-07	29-Mar-98	CPT-LIF			14.51
CCAFB-07-SS01	30-Mar-98	SS		5.50	7.5
CCAFB-07-SS02	30-Mar-98	SS		7.50	9.5
CCAFB-08	29-Mar-98	CPT-LIF			15.03
CCAFB-09	29-Mar-98	CPT-LIF			19.01
CCAFB-10	29-Mar-98	CPT-LIF			18.74
CCAFB-11	29-Mar-98	CPT-LIF			19.00
CCFTA2-07-MW01M	31-Mar-98	MW	Tube		31.50
CCFTA2-CPT-MW01D	30-Mar-98	MW	Riser		52.50
CCFTA2-CPT-MW01M	30-Mar-98	MW	Riser		32.50
CCFTA2-CPT-MW01S	30-Mar-98	MW	Riser		10.00
CCFTA2-CPT-MW02S	31-Mar-98	MW	Riser		8.00
CPFTA2-CPT-MW02M	31-Mar-98	MW	Tube		27.20
CPFTA2-CPT-MW03D	31-Mar-98	MW	Tube		53.00
CPFTA2-CPT-MW03M	31-Mar-98	MW	Tube		31.00
CPFTA2-CPT-MW03S	31-Mar-98	MW	Riser		9.00
CPFTA2-CPT-MW04M	31-Mar-98	MW	Tube		30.00
CPFTA2-CPT-MW04S	31-Mar-98	MW	Riser		8.00

consolidation of the soils can influence tip resistance with both the tip and sleeve stresses increasing as the degree of consolidation increases. Overconsolidation can be caused by previous loading of the soil or desiccation. For a given soil the tip stress increases with depth due to the increase in geostatic stresses.

The friction ratio is a good indicator of the cohesiveness of the soil, which in turn reflects the fine grained soil content. Soils that are predominantly fine grained have friction ratios generally greater than 2, and sandy soils have ratios of 2 or less. Weak and sensitive clays will have friction ratios of less than 2. The penetration pore pressure response is a function of the soil's shear strength and stiffness, hydraulic conductivity and density. For normally consolidated soils, the penetration pore pressure will be greater than the static pore pressure for clays and silts and equal to the static pore pressure for clean sands. In overconsolidated, dense soils the pore pressure response can be less than the static pore pressure, especially in those soils that tend to dilate, such as silty sands. The combination of the friction ratio and pore pressure response provides a good identification of the soil lithology. With this basic understanding of the CPT data, an analyst can interpret the lithology and soil classifications visually as described below.

A typical penetration profile from Patrick AFB is presented in Figure 2. This profile (CPT-86-02-LIF) was completed to a depth of 15.4 ft below ground surface (bgs) and is representative of the geologic conditions at Patrick AFB. This profile includes the sleeve stress, tip resistance, friction ratio, penetration pore pressure, and baseline LIF counts measured during the test, along with the soil classification and soil lithology derived from the data. For location CPT-86-02-LIF, the friction ratio is fairly consistent throughout the profile. The classification profile derived from the friction ratio and pore-water pressure data indicates that the sediments consist of various gradations of sand. There are two zones at a depth of approximately 4 and 8.5 feet bgs that yield slightly higher friction ratios. These two zones represent transitions into finer grained soils. At approximately 9.5 feet bgs, the tip and sleeve stresses both increase somewhat linearly indicating zones of overconsolidated deposits.

CPT-86-02-LIF APPLIED RESEARCH ASSOCIATES, INC. 03/21/94

North 455 East 346 Elevation 7.07

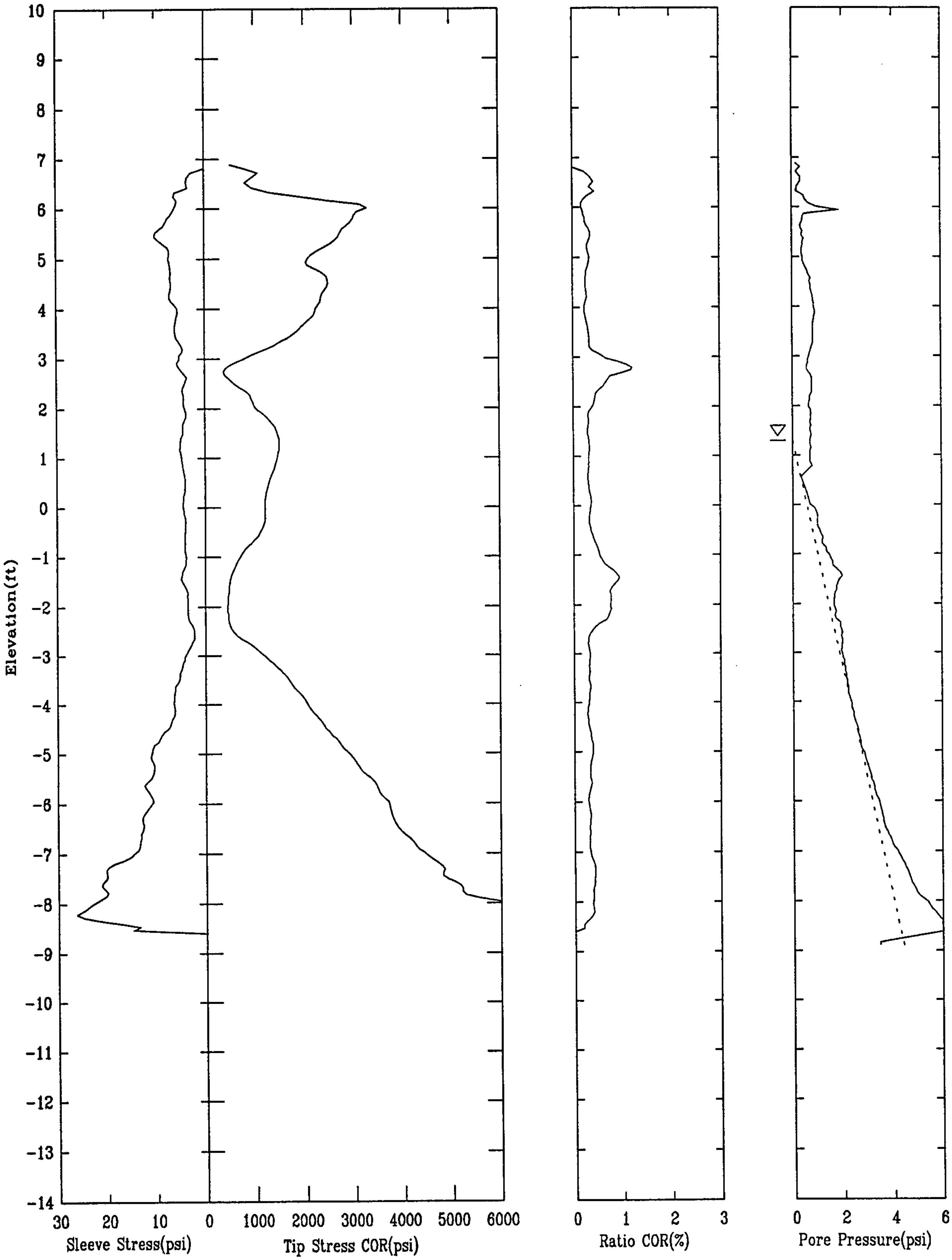


Figure 2. LIF-CPT profiles for CPT-86-02-LIF.

North 455 East 346 Elevation 7.07

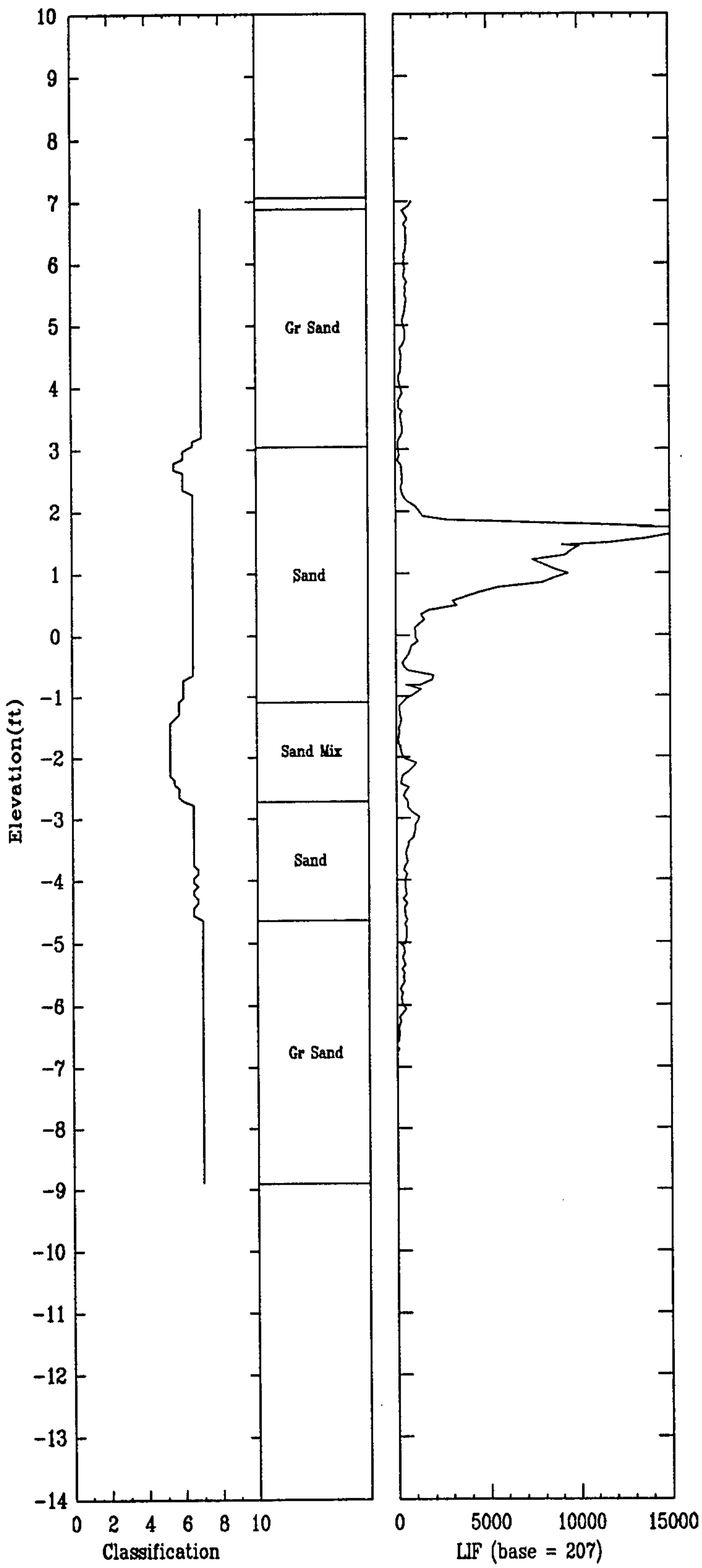


Figure 2. LIF-CPT profiles for CPT-86-02-LIF (continued).

Interpretation of LIF Profiles

The LIF system accumulates data at a rate of approximately one (1) waveform per second, which correlates to one waveform every 2 centimeters as the LIF sensor is advanced into the formation. Each waveform consists of 125 data points, and when integrated yields the LIF-intensity value at a particular depth. The LIF data files showed a baseline-shift, apparently due to background noise from various sources. To compensate for this shift, the data sets were modified by subtracting out the average of the first five data points in each waveform before integration. This produces a waveform with a zero baseline. To compensate for instrument fluctuations, the LIF profile is further modified. The median of the lowest 41 LIF intensity values is subtracted from all LIF values in that profile. This number is called the time base for that profile. The data is subsequently plotted incorporating the above modifications.

The LIF profile for CPT-86-02-LIF shown in Figure 2 shows a significant LIF response at approximately 5 feet bgs. This correlates well with the estimated depth of the water table located at 5.5 feet bgs. This suggests that the LNAPL contamination lies at or slightly above the water table at this location. This profile is included in Appendix A along with the profiles from all of the doundings completed at both Patrick AFB and Kennedy Space Center.

CONCLUSIONS

The CPT-LIF proved a useful and efficient tool for conducting subsurface site investigations at both the SS-29 site located at Patrick AFB in Cocoa Beach, FL and the former fire training facility located at the Kennedy Space Center, Cape Canaveral, FL. The CPT data accurately described the lithology of the SS-29 site as various gradations of sands with occasional discontinuous seams of silty clays and clay. This interpretation closely matches interpretations described by others during previous investigations. The CPT data was used to effectively set monitoring wells and collect soil samples. The LIF data assisted in defining both the horizontal and vertical extent of the liquid phase plume. A complete

analytical report assessing all the data collected during the course of this investigation including the groundwater and soil chemical analytical data will be forthcoming.

REFERENCES

1. Engineering-Science, Inc. (ES), "Draft Work Plan for an Engineering Evaluation/Cost Analysis in Support of the Intrinsic Remediation (Natural Attenuation) Option," for Patrick AFB, Florida, ES, Denver, Colorado, March 1994.

2. Environmental Science and Engineering, Inc. (ESE), "Installation Restoration Program, Air Force Installation Restoration Program, Phase II, stage 2, Remedial Investigation/Feasibility Study, for Patrick Air Force Base, Cocoa Beach, Florida," Vol. I through Vol X, Gainesville, Florida, 1991.

3. O'Brien and Gere Engineers, Inc., "ST-29 (PPOL-2) Work Plan Draft Final Report," Patrick AFB, Florida.

4. Environmental Science & Engineering, Inc. (ESE), "Installation Restoration Program, Phase II: Confirmation/Quantification, stage I, Patrick Air Force Base, Florida," Vol. I and Vol. II, 1988.

5. Engineering-Science, Inc. (ES), "Bioventing Test Work Plan and Interim Results Report for Three Bioventing Sites, Patrick Air Force Base and Cape Canaveral Air Force Stateion, Florida," Prepared for the Air Force Center for Environmental Excellence and 45CES/DEEV, Patrick Air Force Base, Florida, ES, Orlando, Florida, June, 1993.

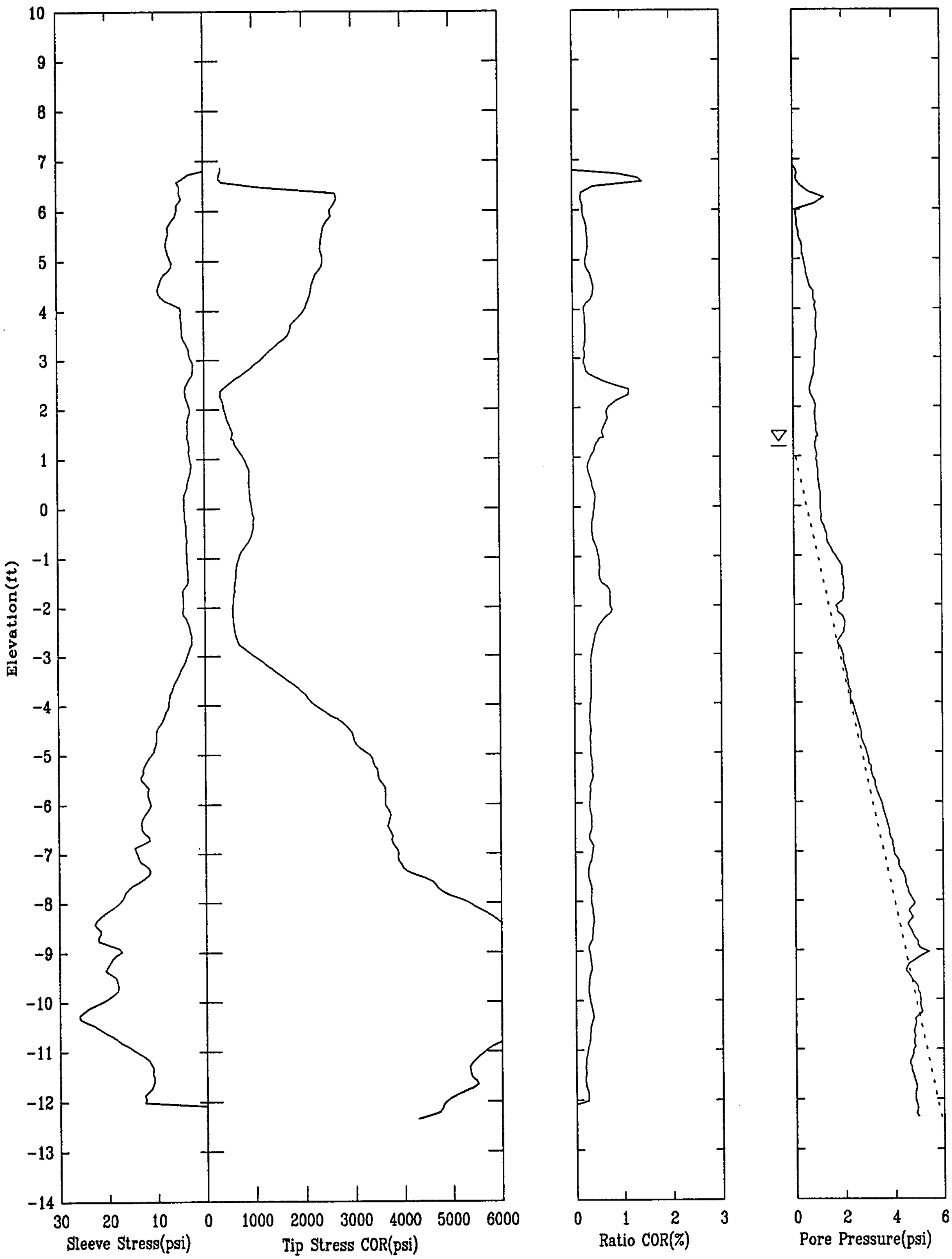
6. Environmental Science and Engineering, Inc. (ESE), " Installation Restoration Program, Phase I: Records Search, Eastern Space and Missile Center: Patrick Air Force Base, Florida," Gainseville, Florida, 1984.

APPENDIX A

LIF-CPT SOUNDING PROFILES

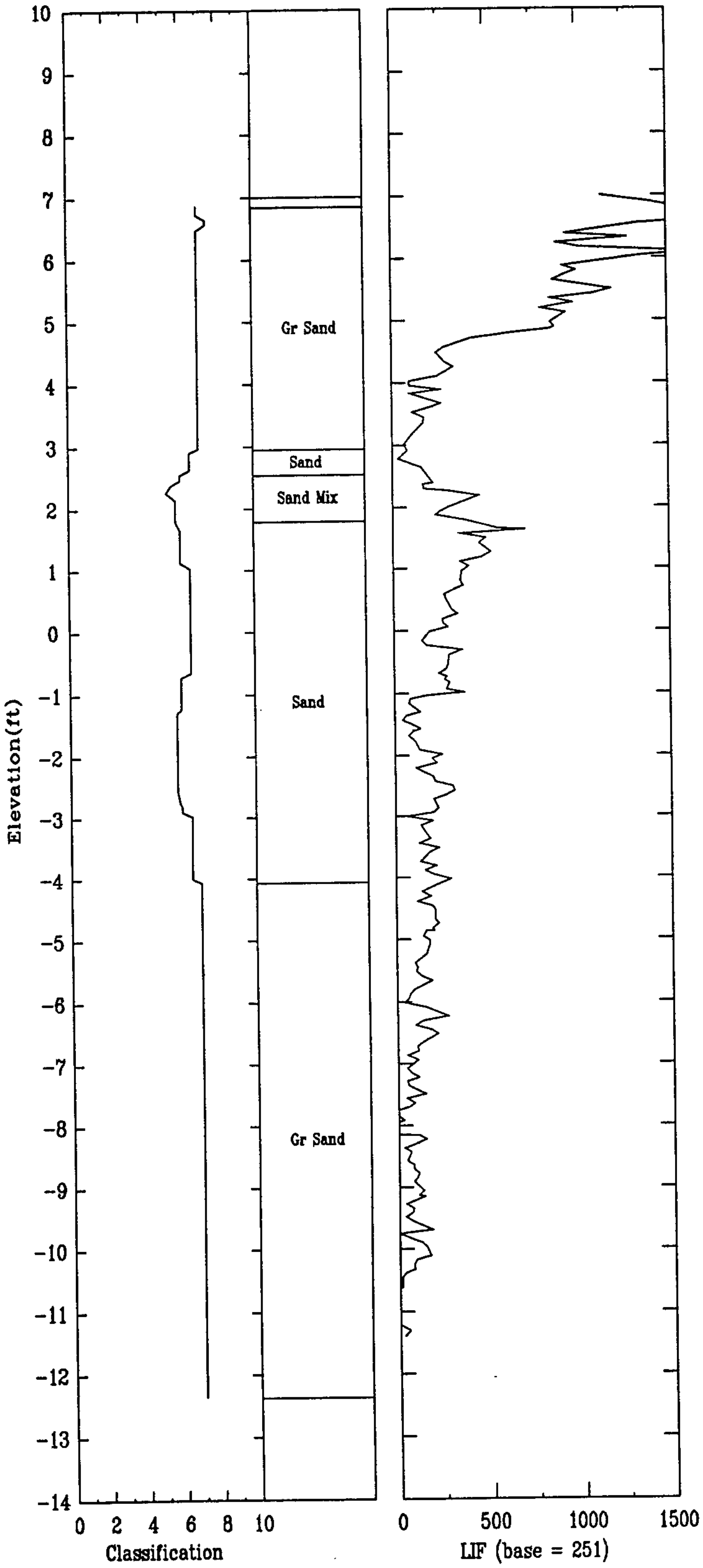
CPT-86-01-LIF APPLIED RESEARCH ASSOCIATES, INC. 03/21/94

North 491 East 363 Elevation 7.02



CPT-86-01-LIF APPLIED RESEARCH ASSOCIATES, INC. 03/21/94

North 491 East 363 Elevation 7.02



CPT-86-02-LIF APPLIED RESEARCH ASSOCIATES, INC. 03/21/94

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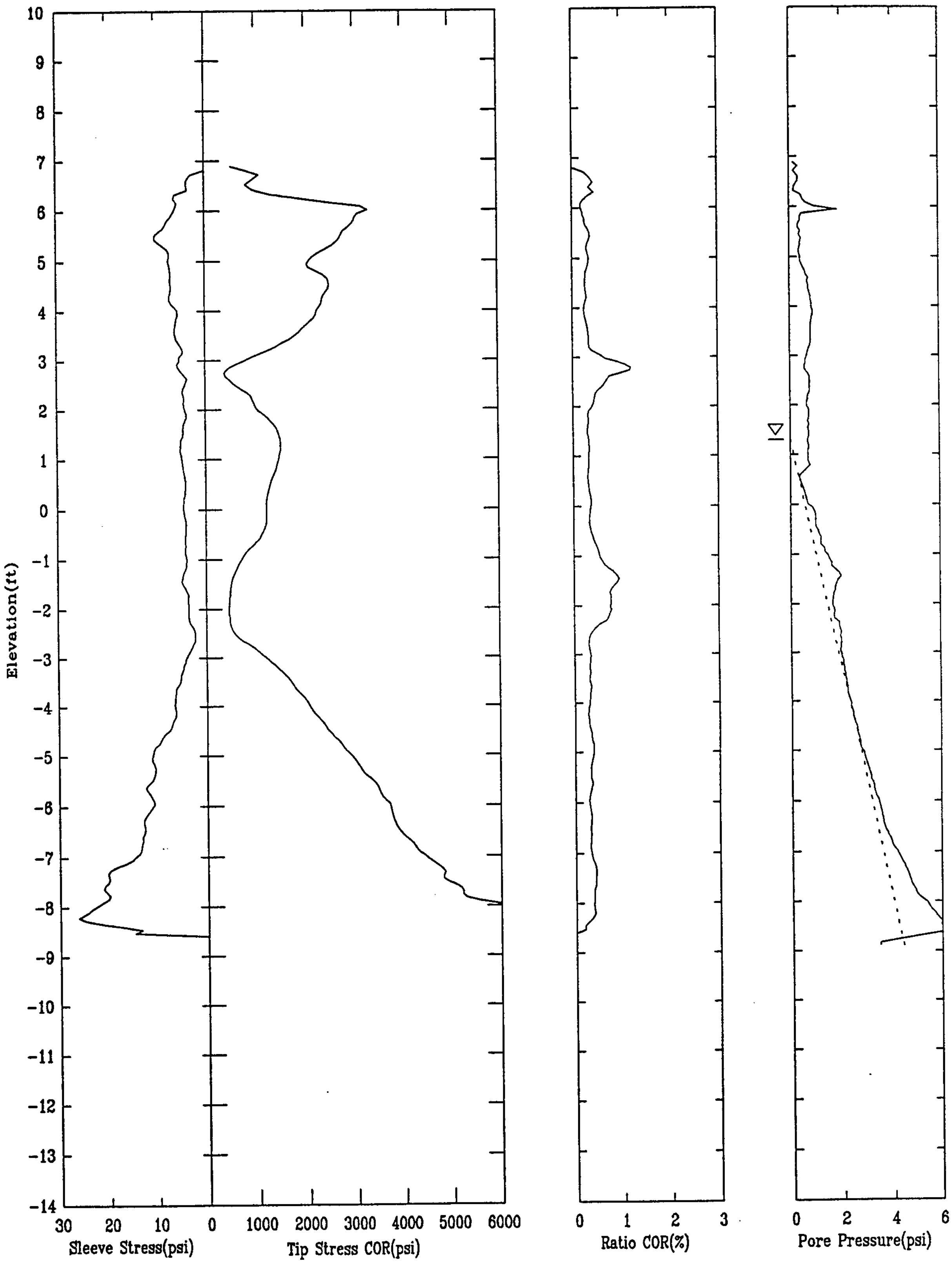
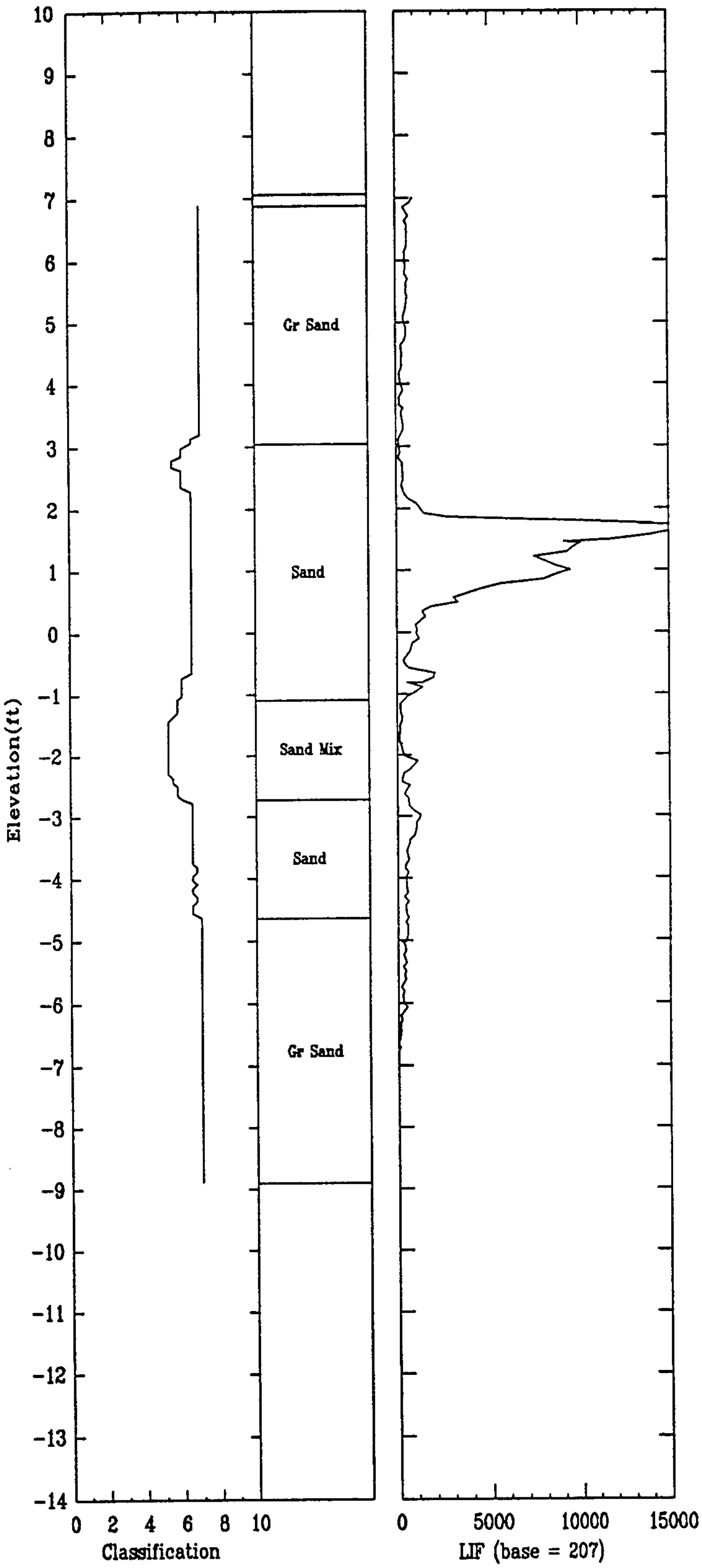


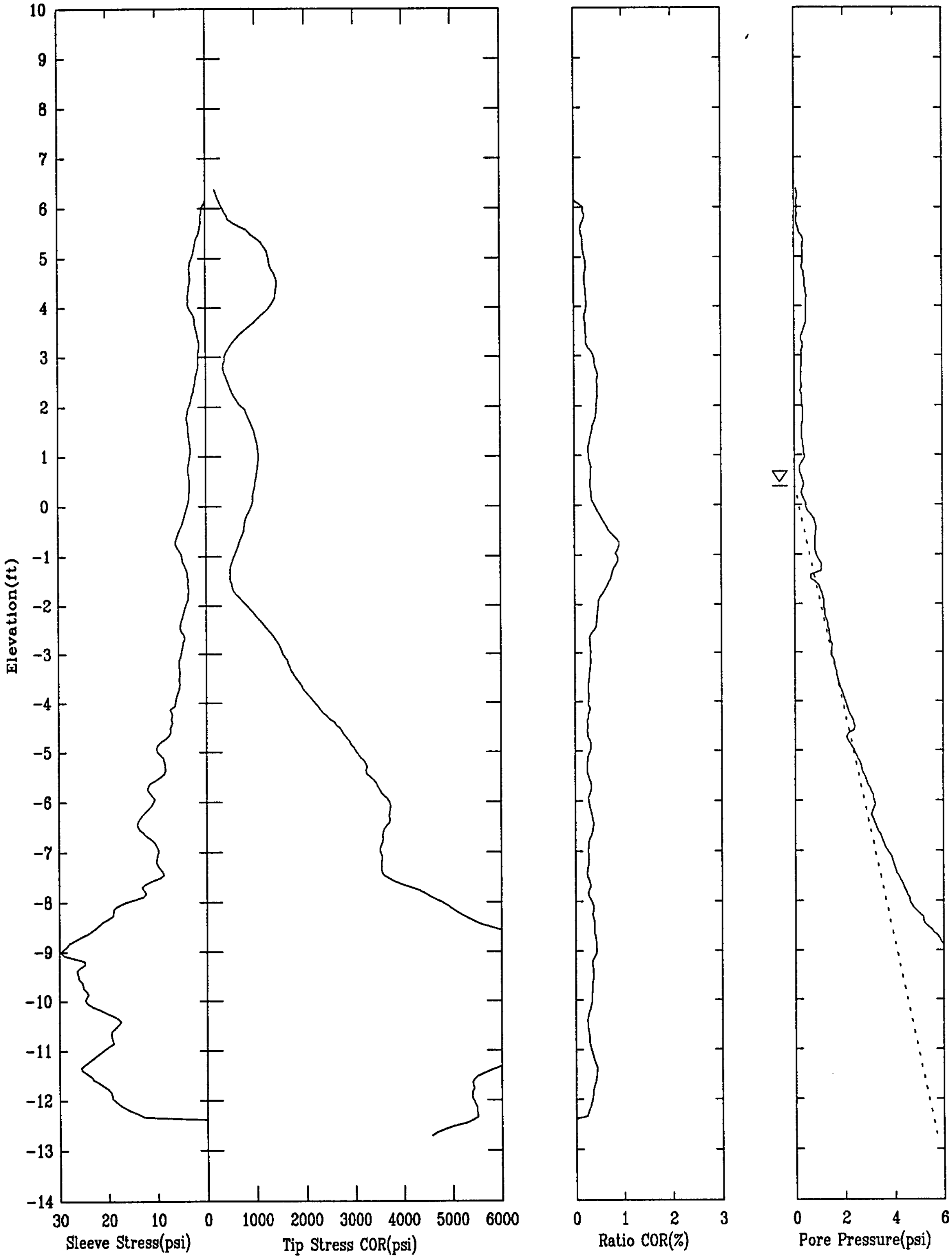
CPT-86-02-LIF APPLIED RESEARCH ASSOCIATES, INC. 03/21/94

North 455 East 346 Elevation 7.07



CPT-86-03-LIF APPLIED RESEARCH ASSOCIATES, INC. 03/21/94

North 420 East 319 Elevation 6.55



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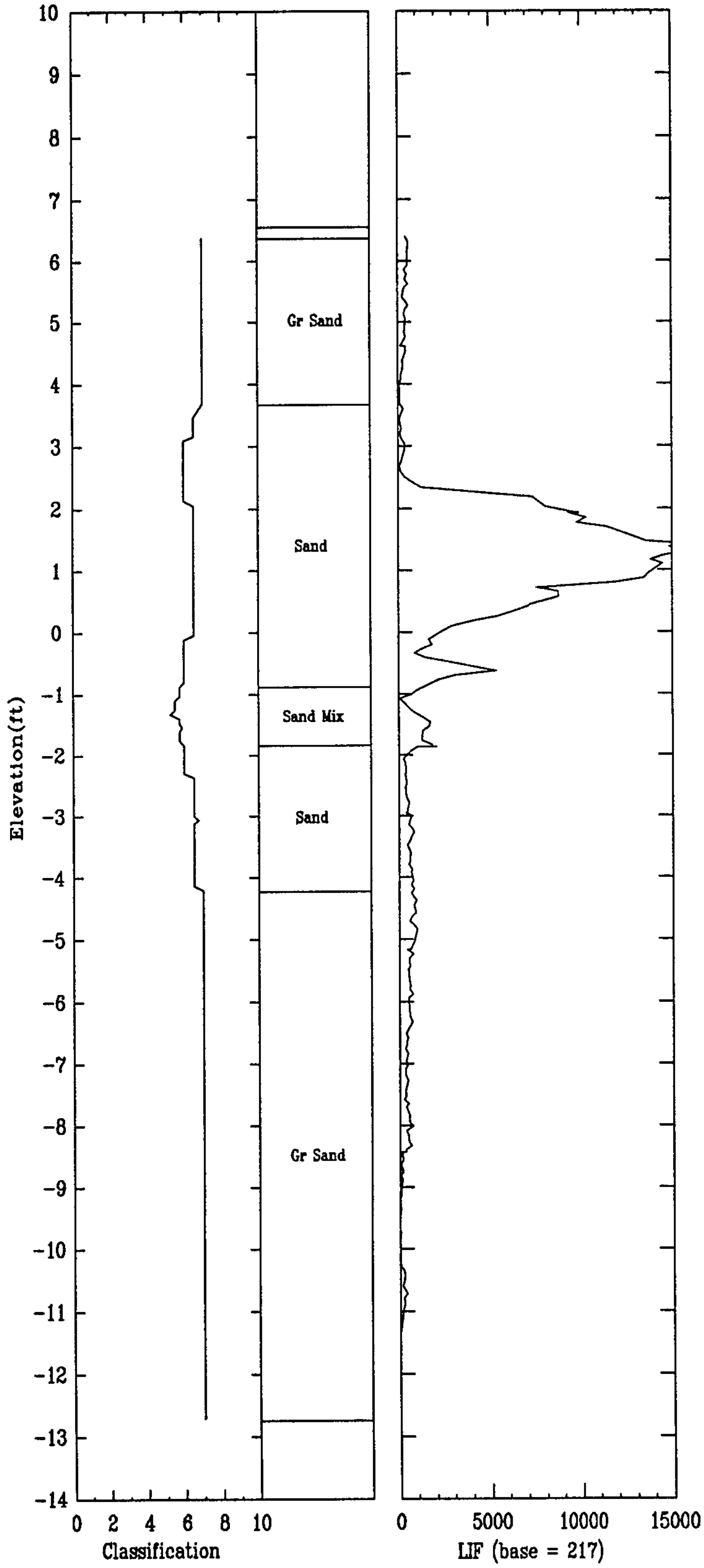
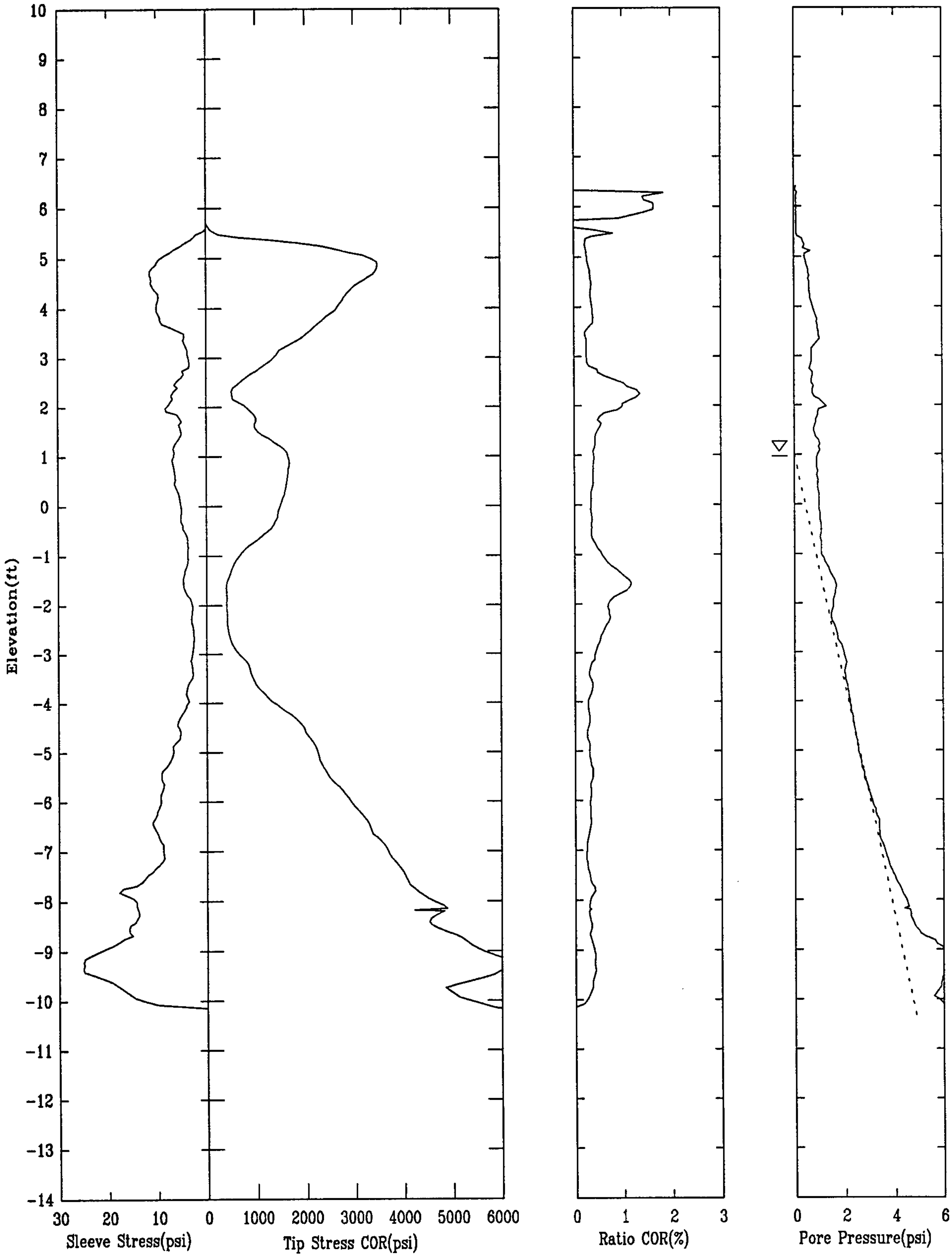
North 420 East 319 Elevation 6.55



CPT-86-04-LIF APPLIED RESEARCH ASSOCIATES, INC. 03/21/94

North 443 East 133 Elevation 6.57



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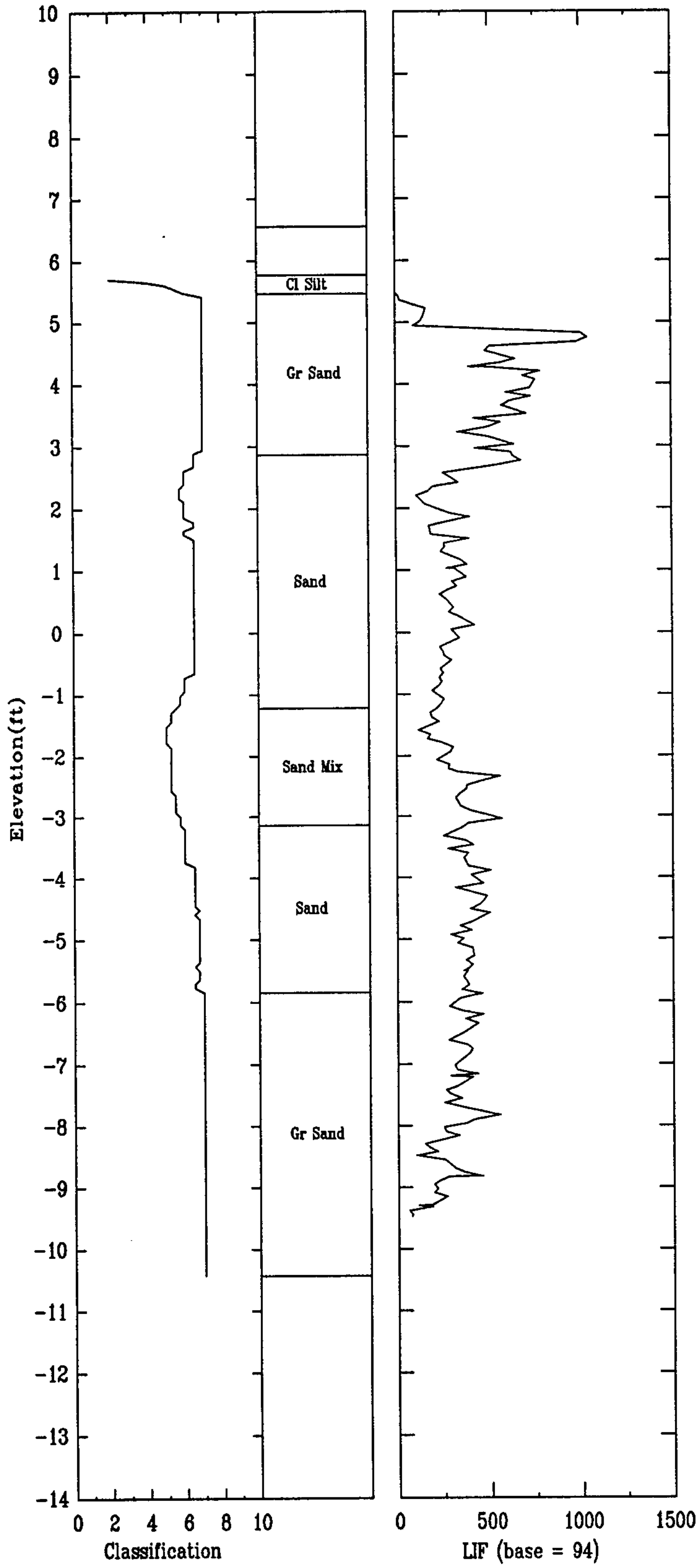
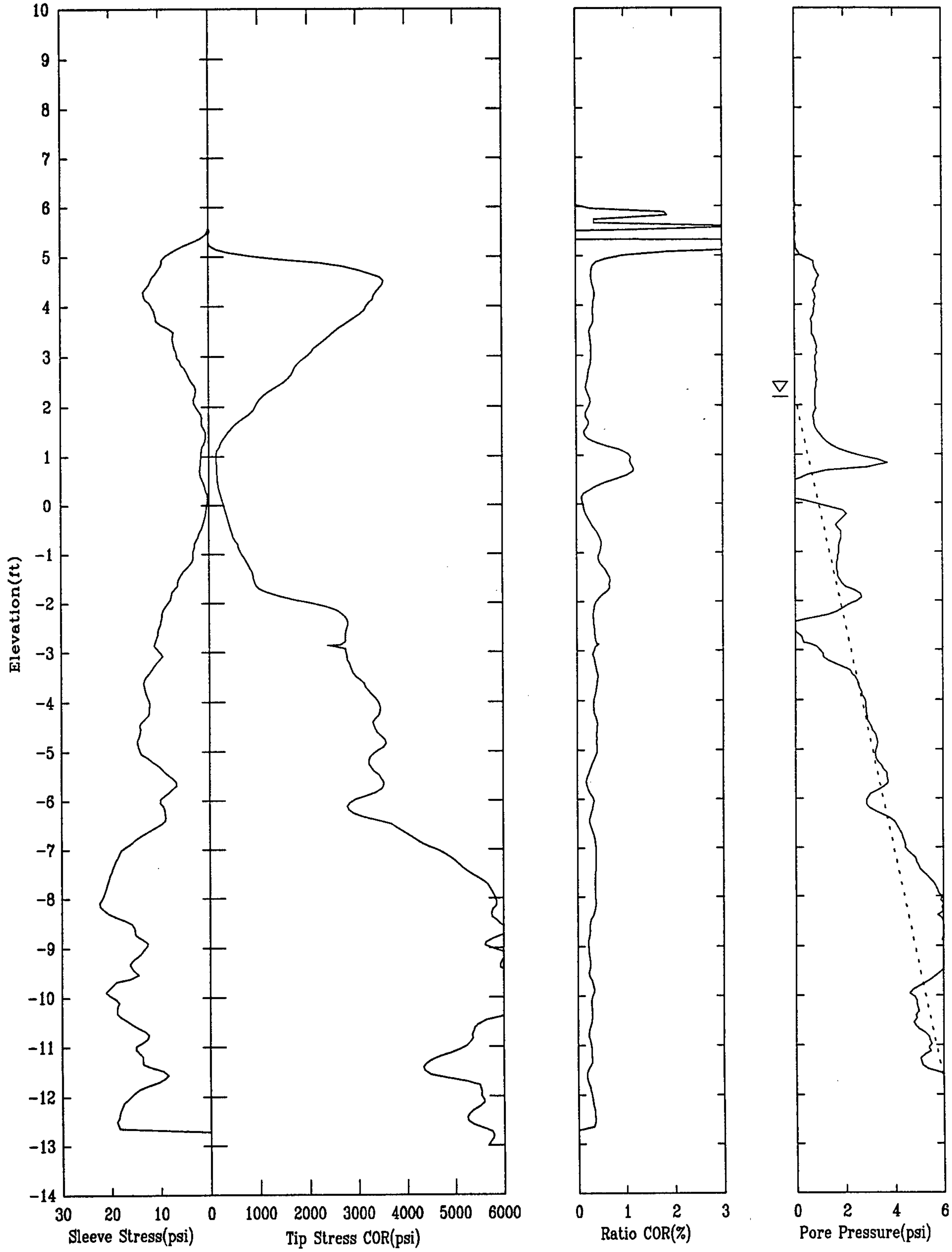
North 443 East 133 Elevation 6.57



CPT-86-05-LIF APPLIED RESEARCH ASSOCIATES, INC. 03/22/94

North 423 East 266 Elevation 6.26



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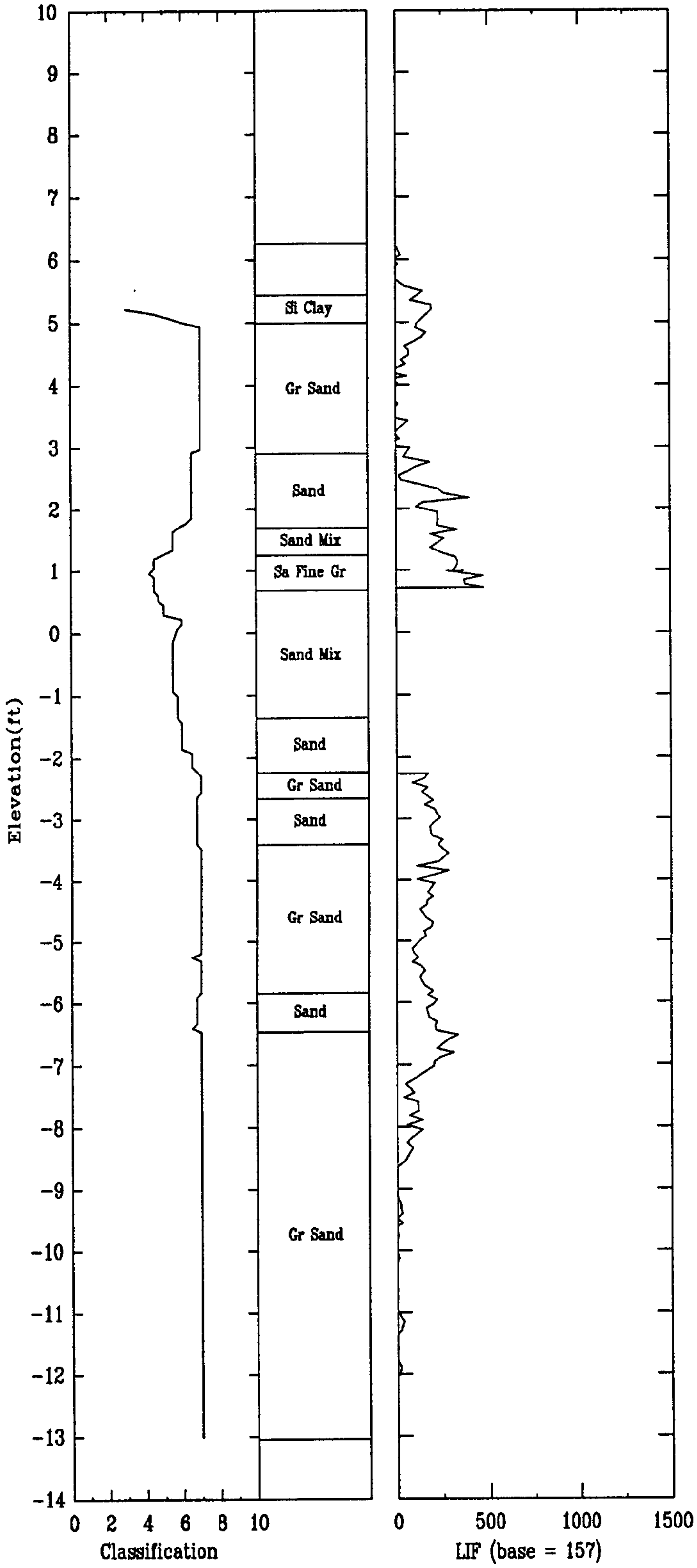

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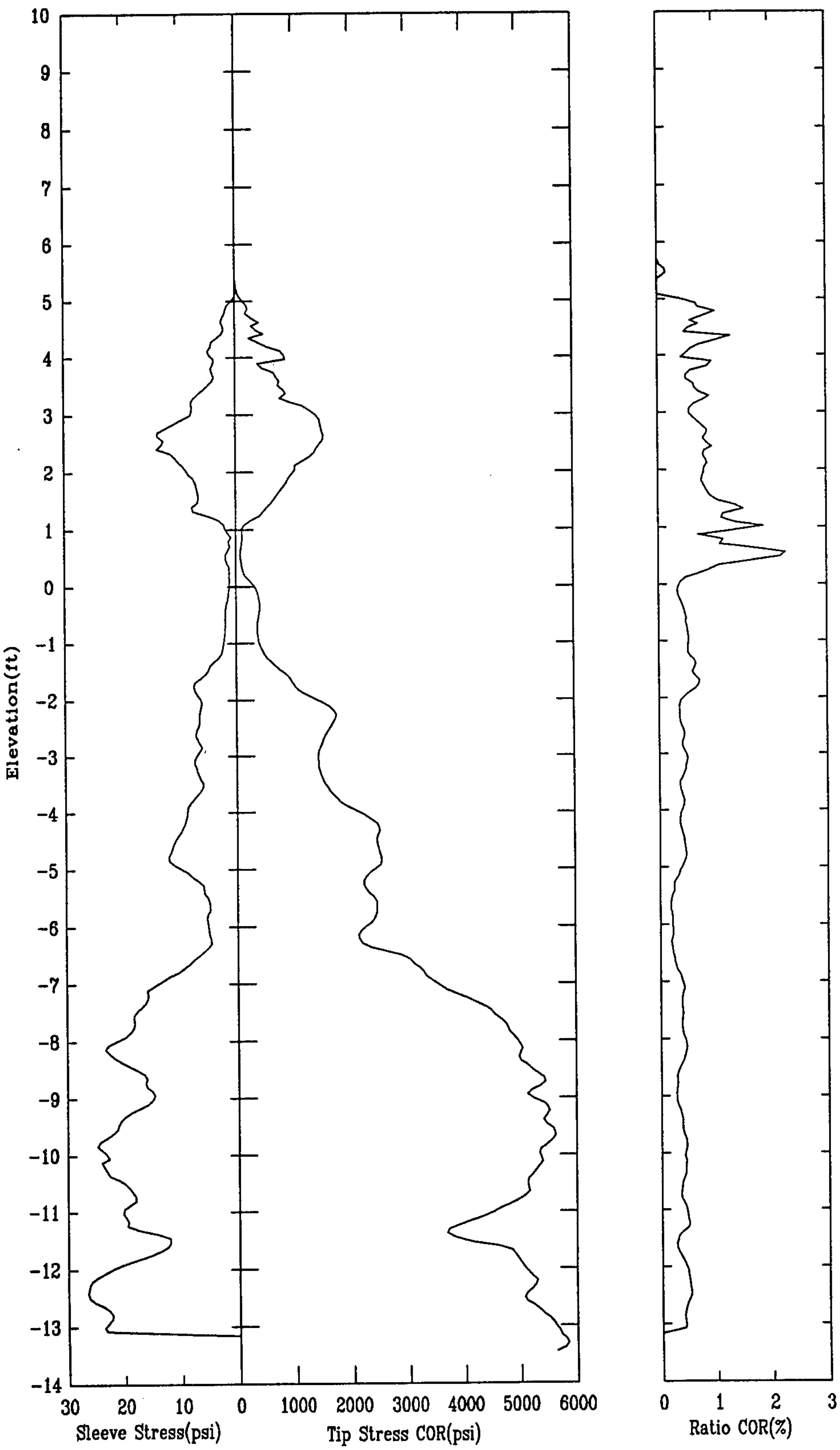

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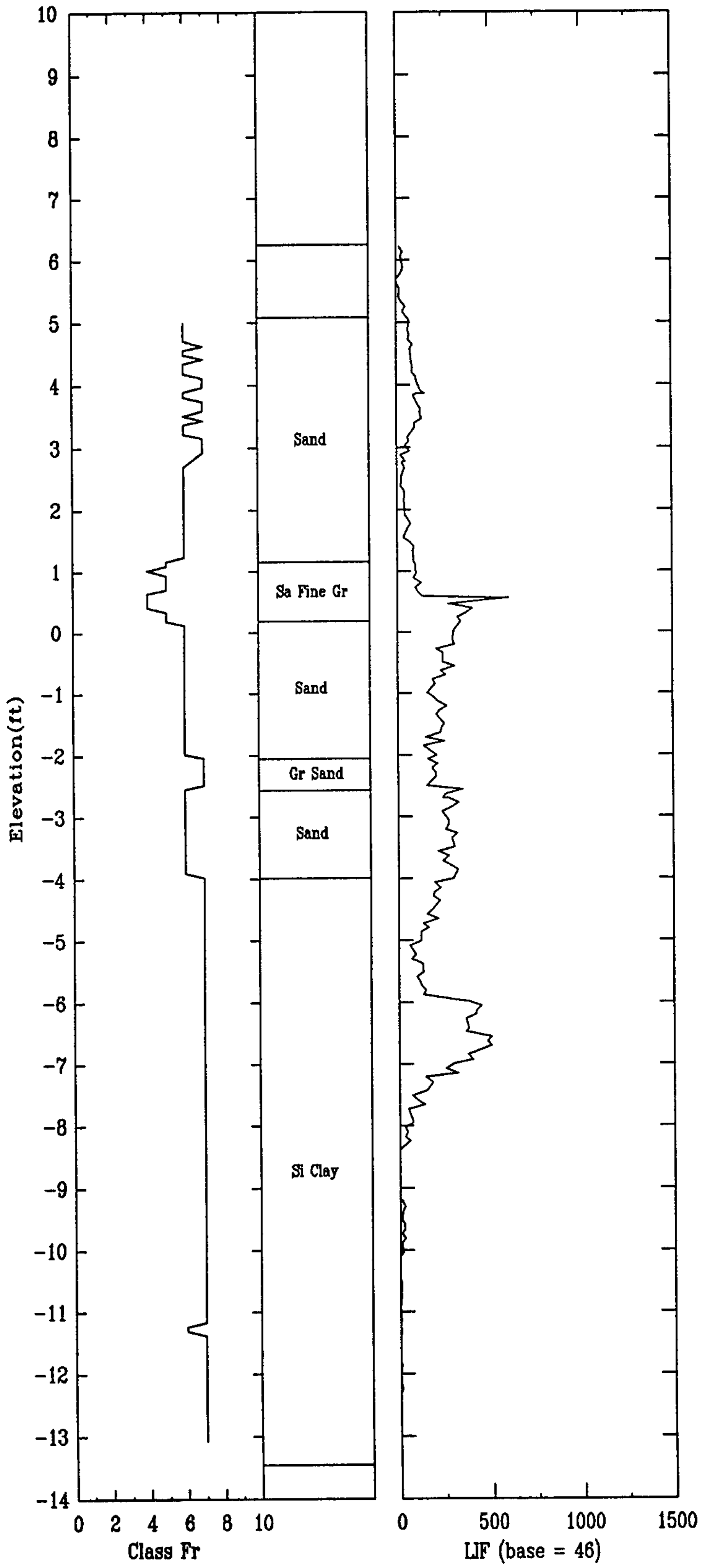
North 423 East 266 Elevation 6.26



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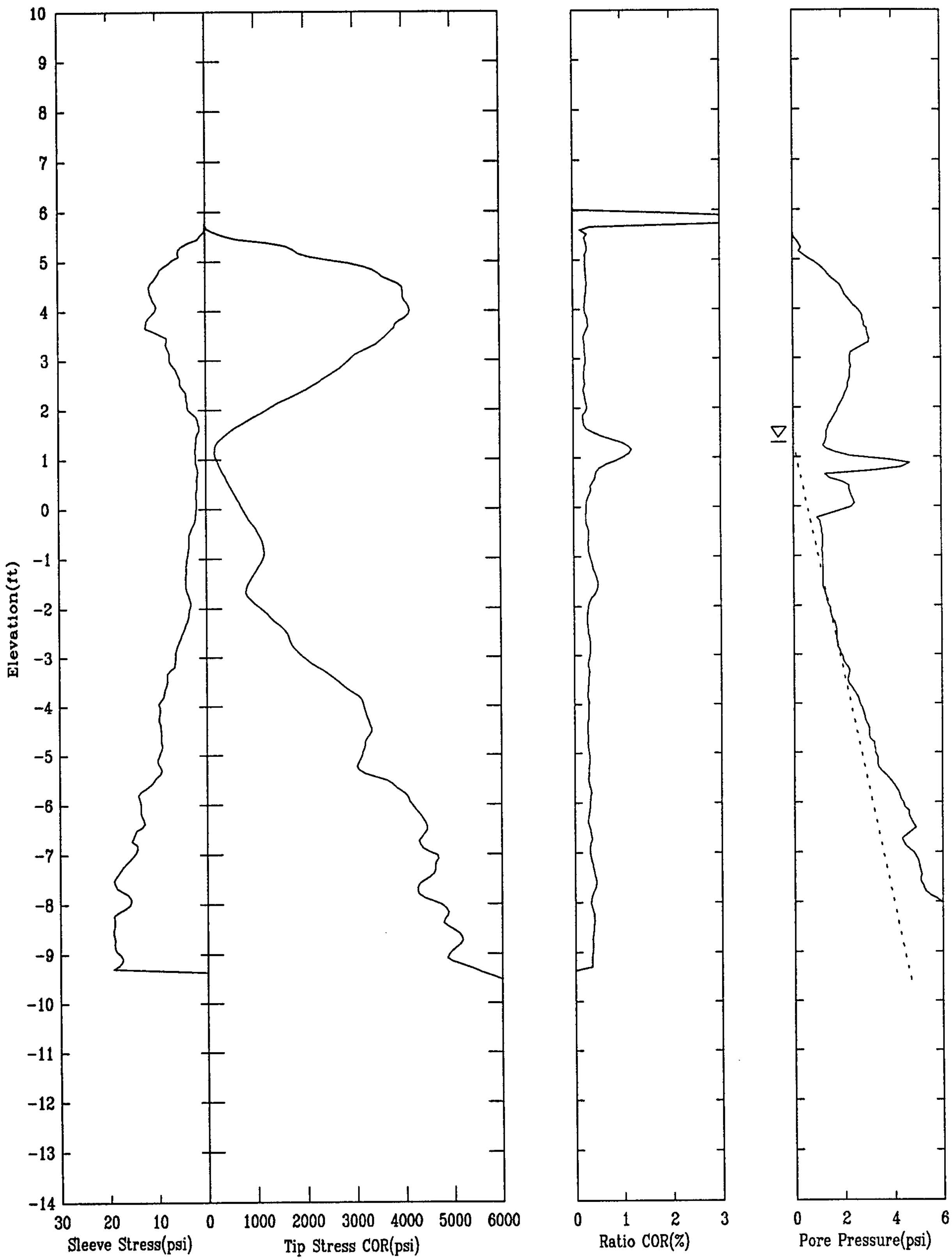
North 381 East 248 Elevation 6.26



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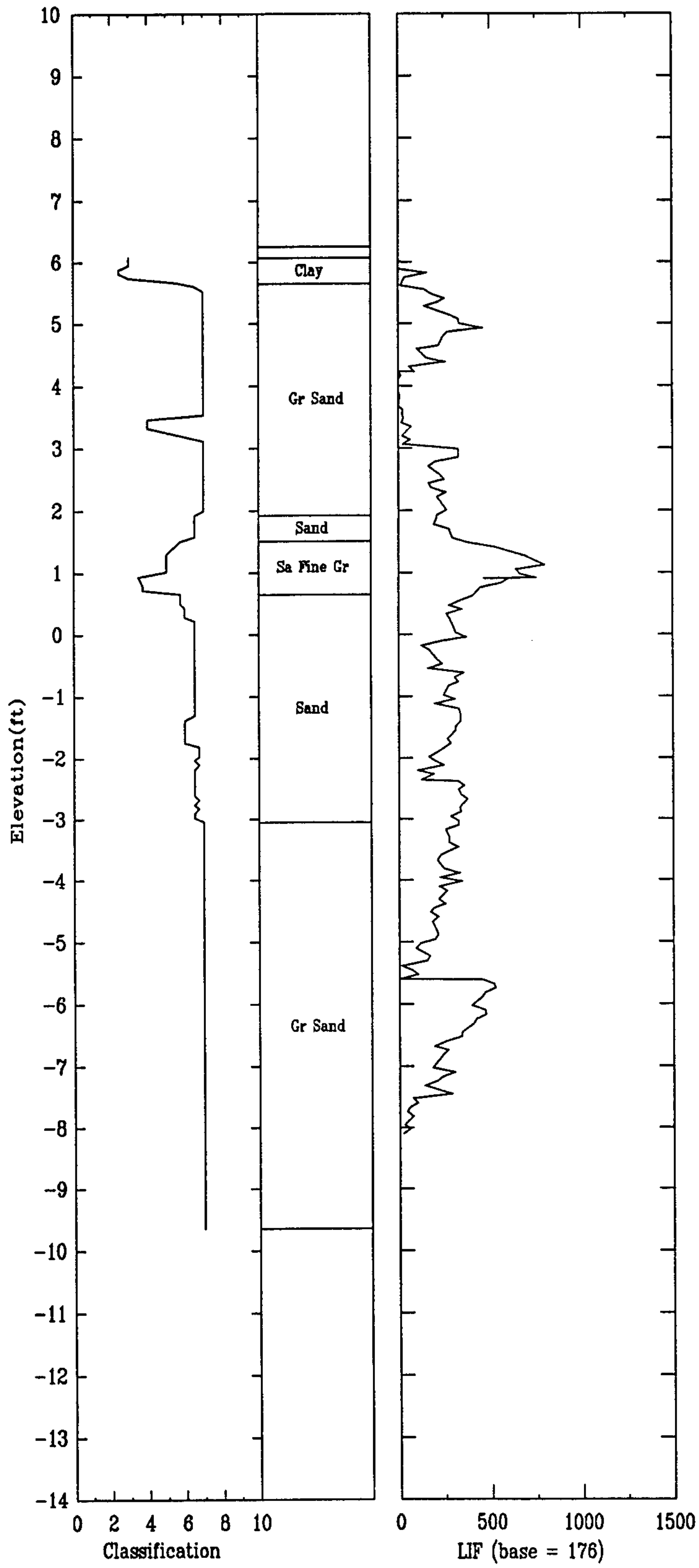
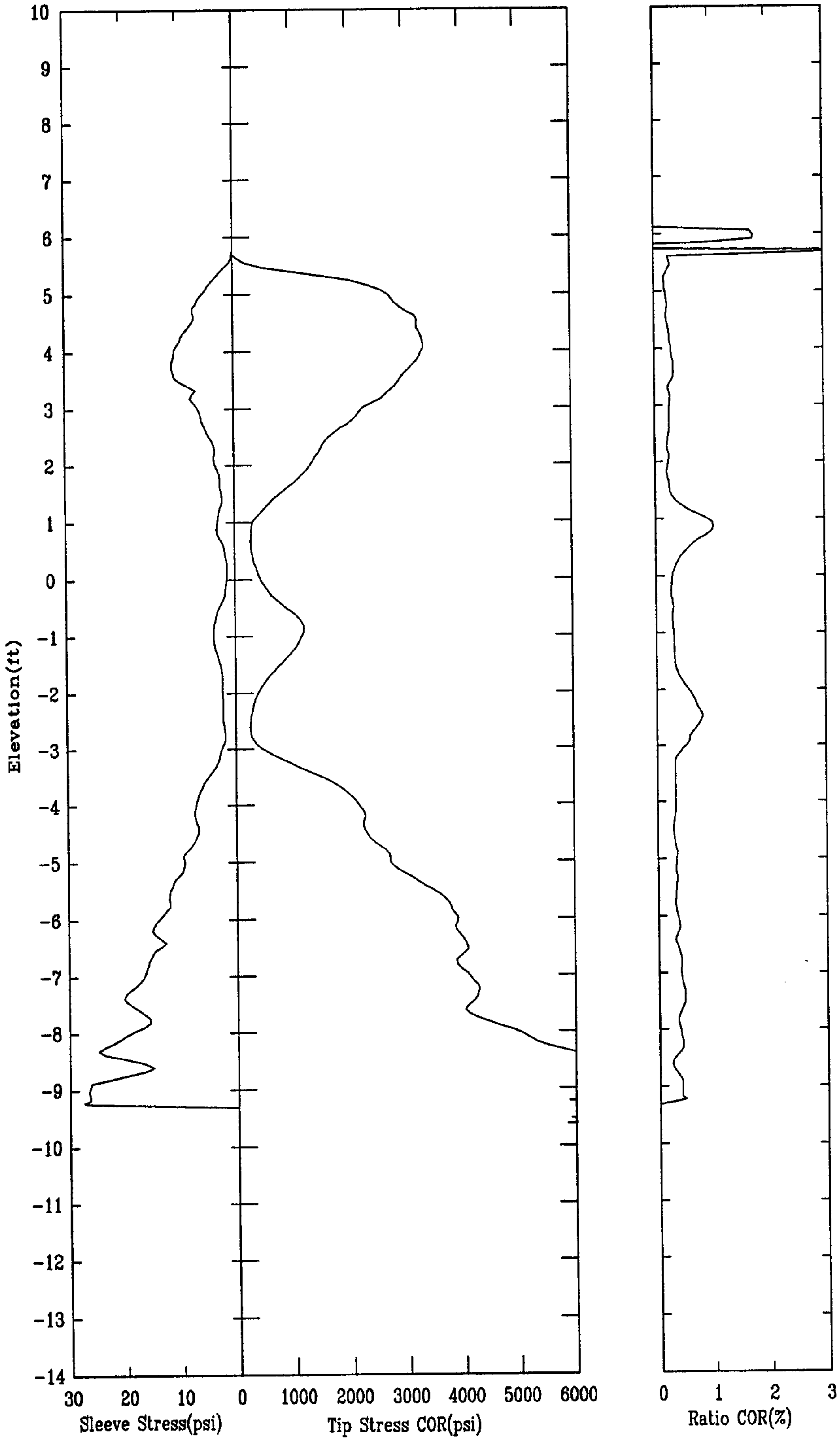


CPT-86-07-LIF APPLIED RESEARCH ASSOCIATES, INC. 03/22/94

North 354 East 235 Elevation 6.36



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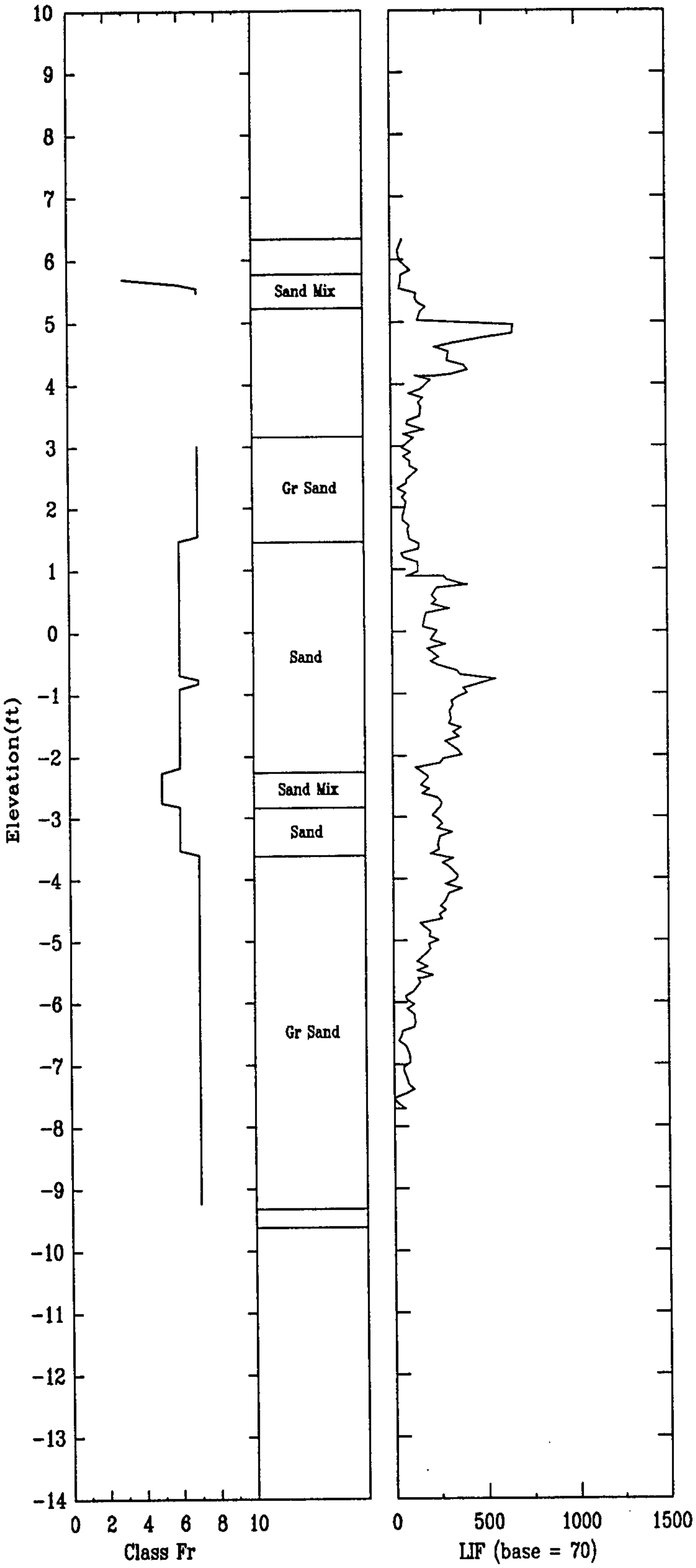

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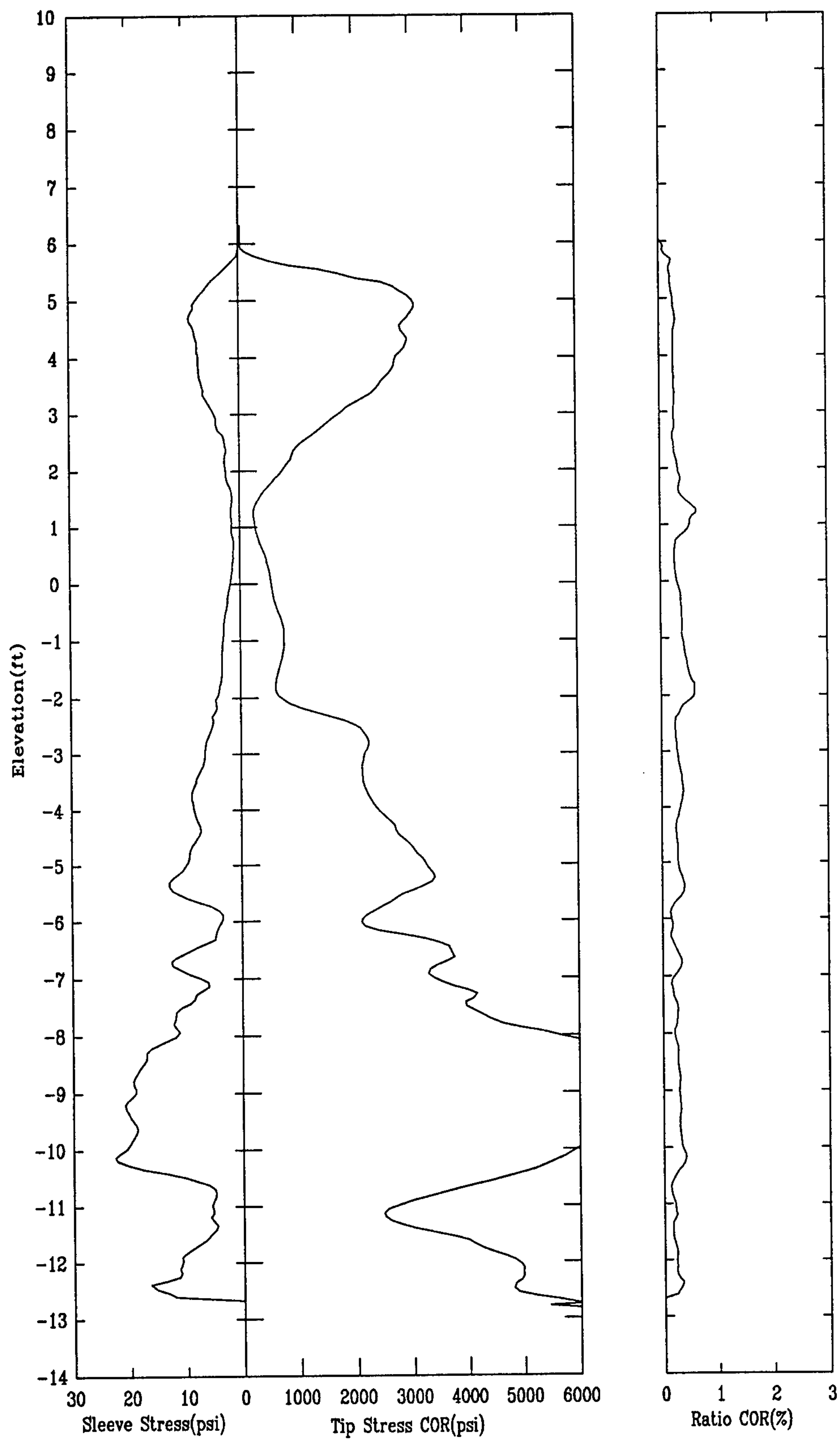
North 343 East 262 Elevation 6.48



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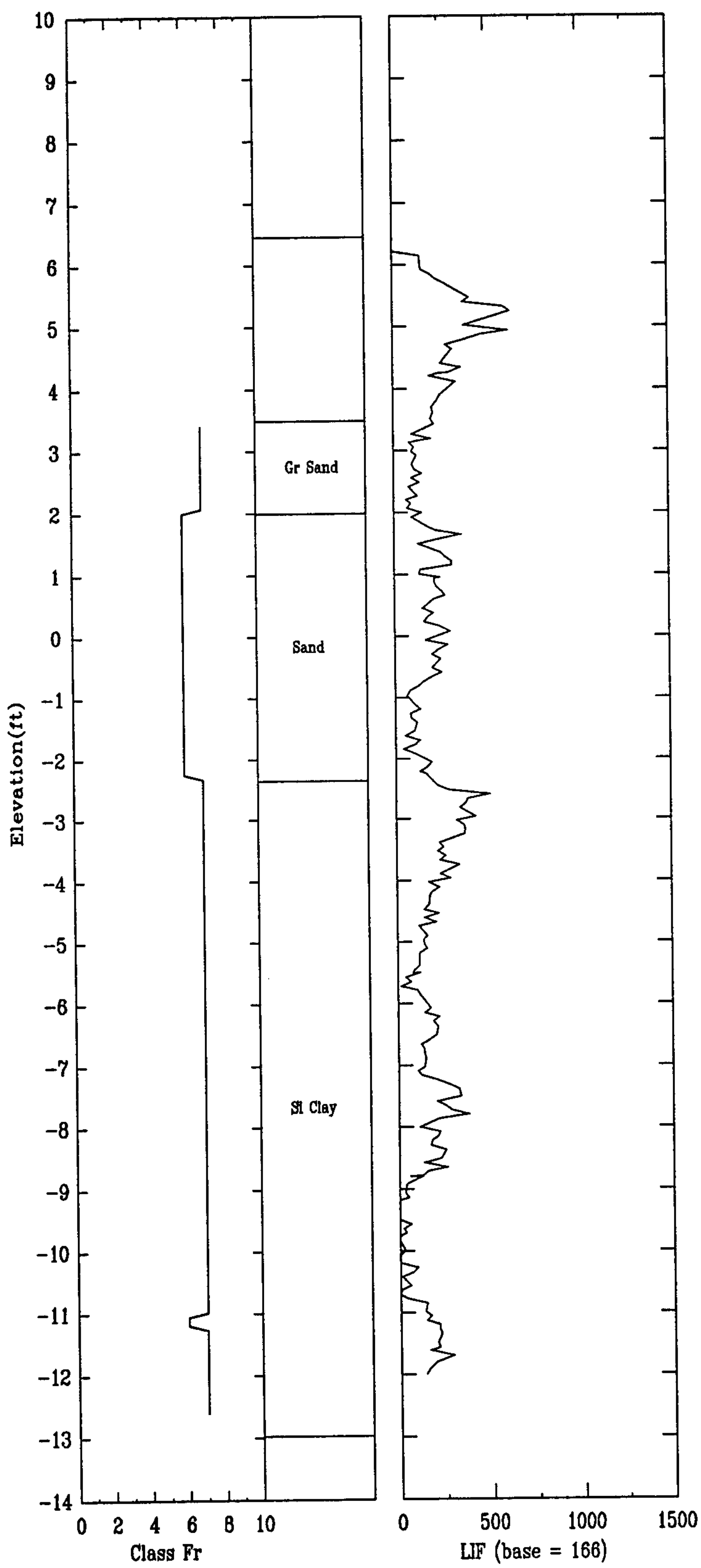
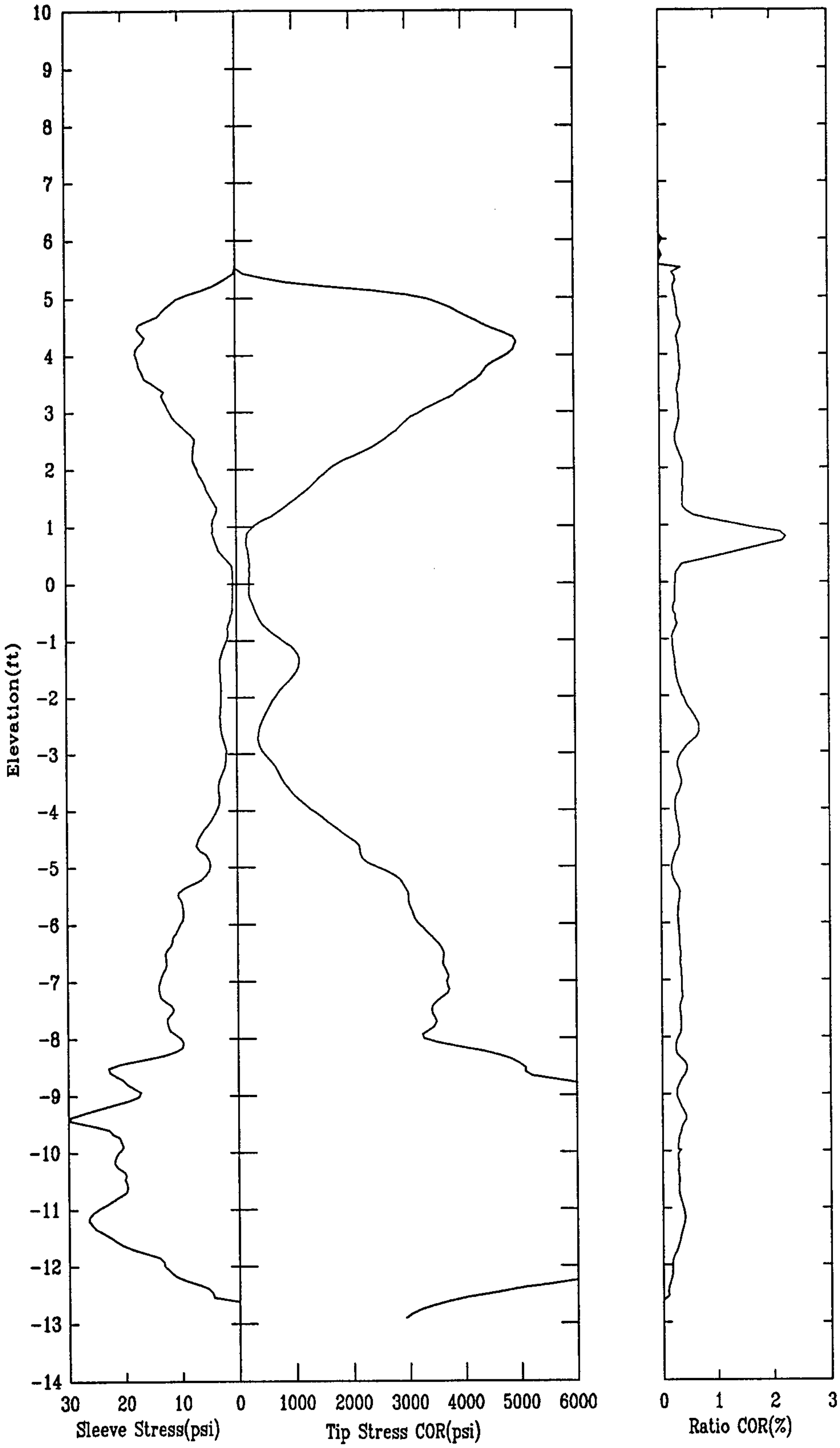


North 428 East 240 Elevation 6.35



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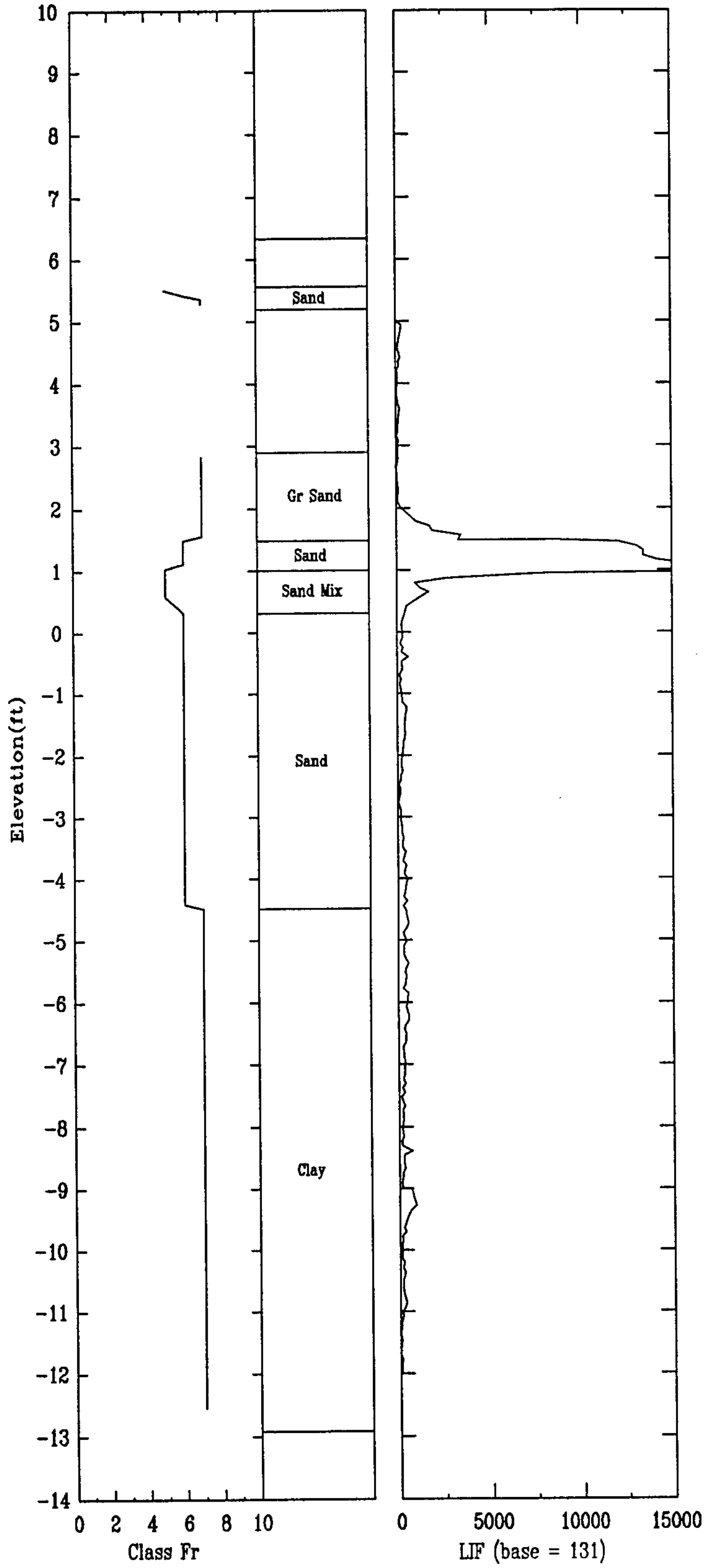

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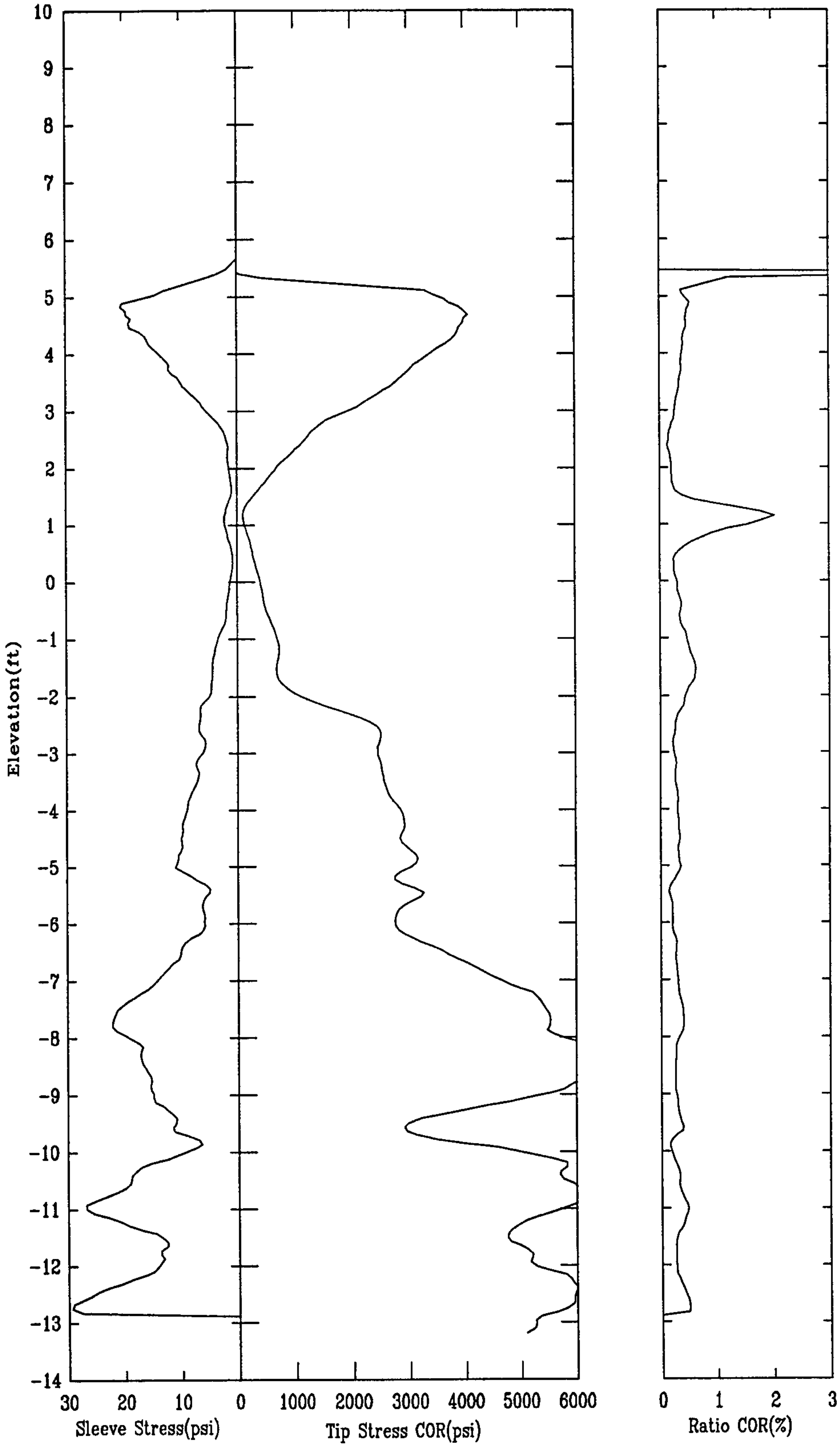

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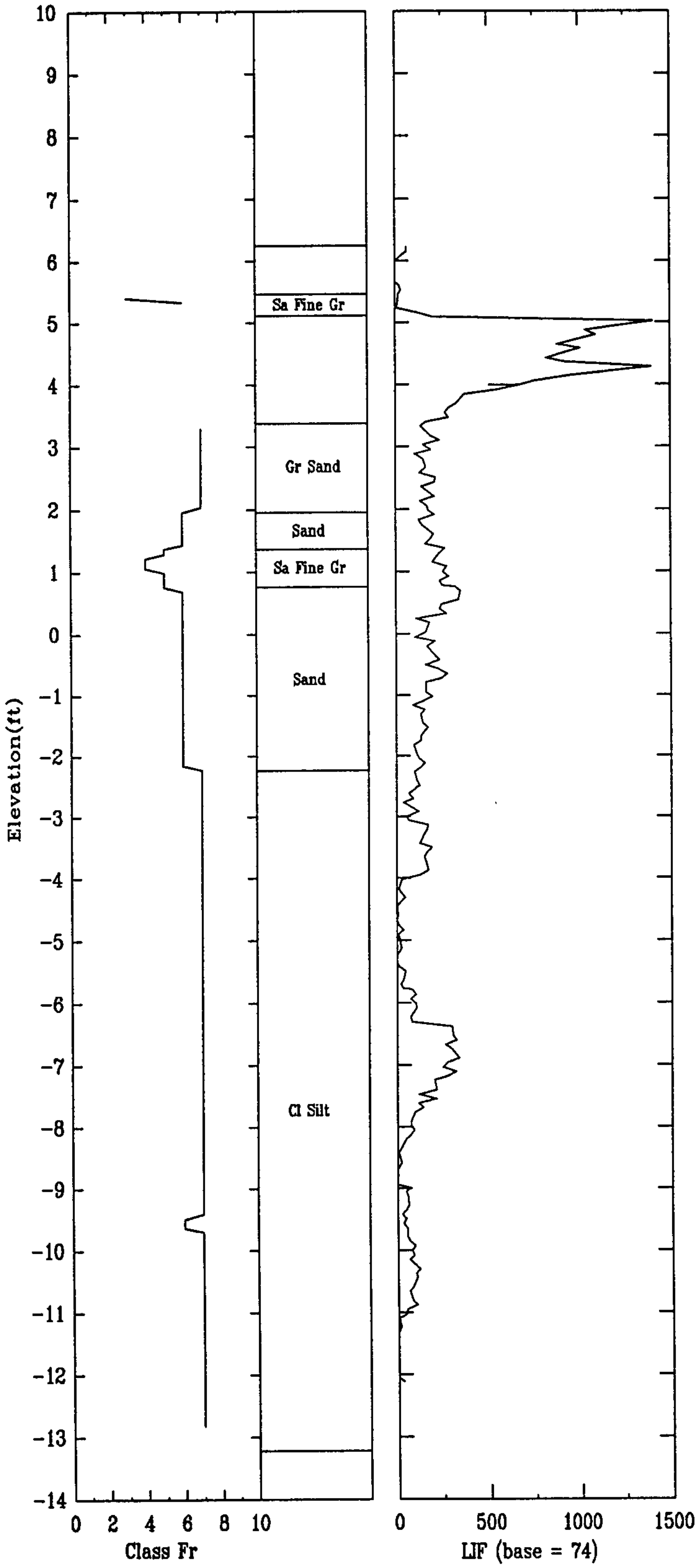

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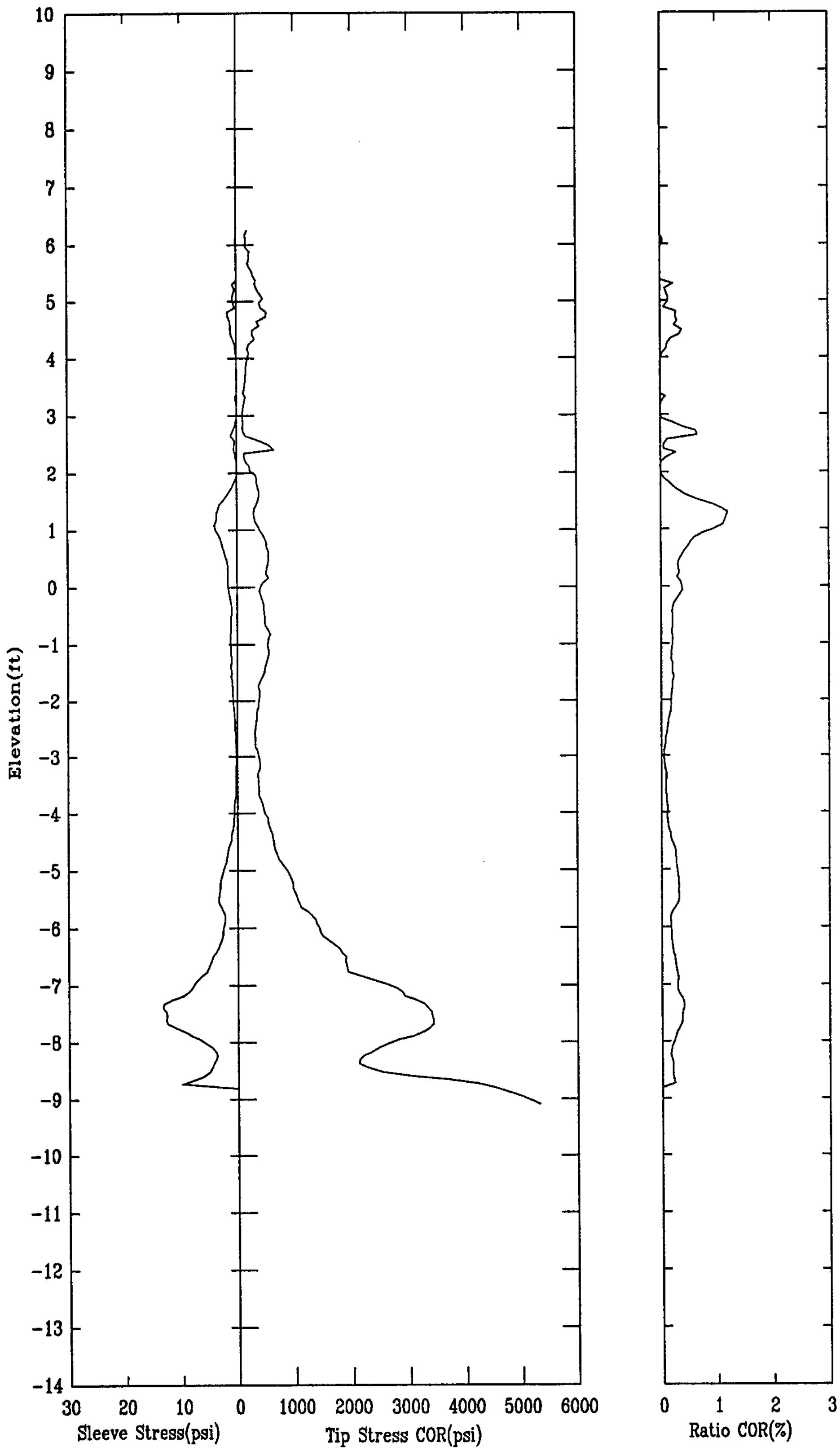

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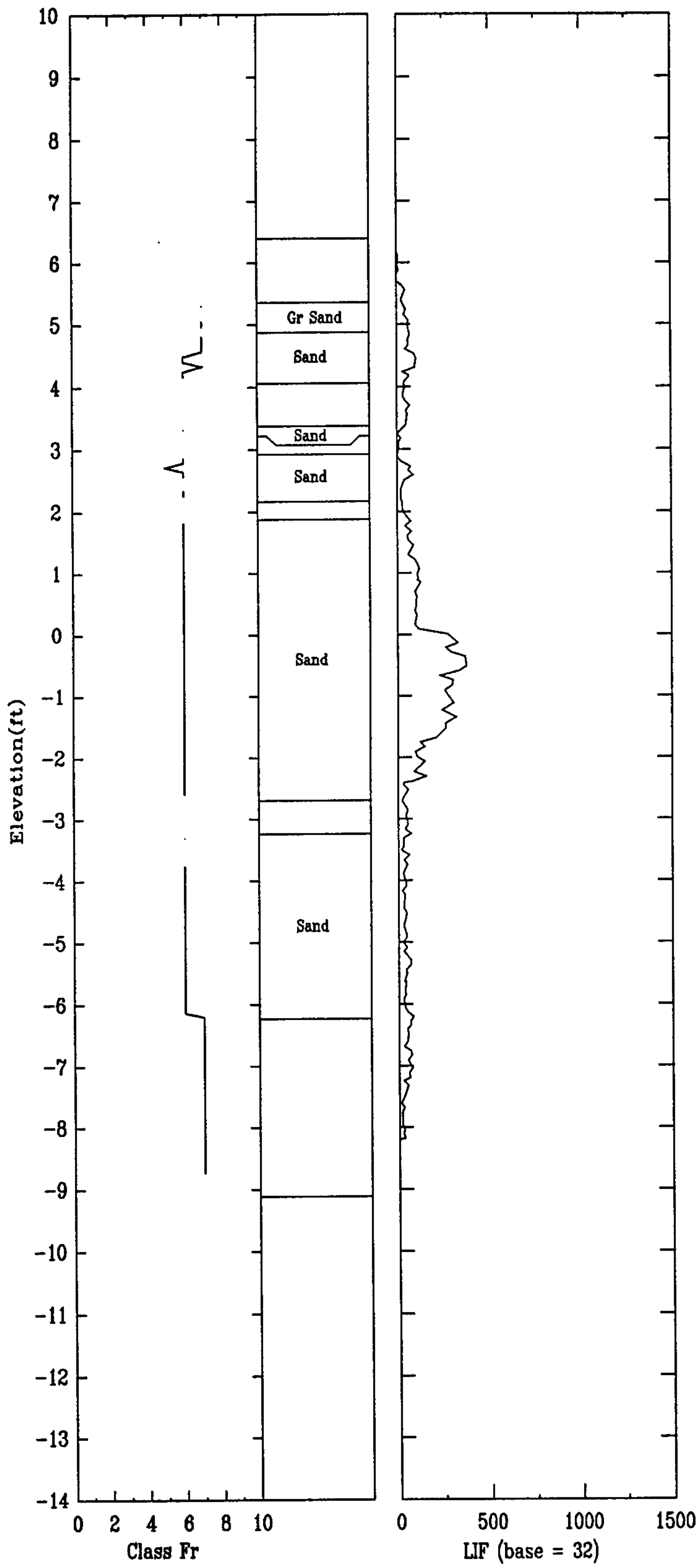

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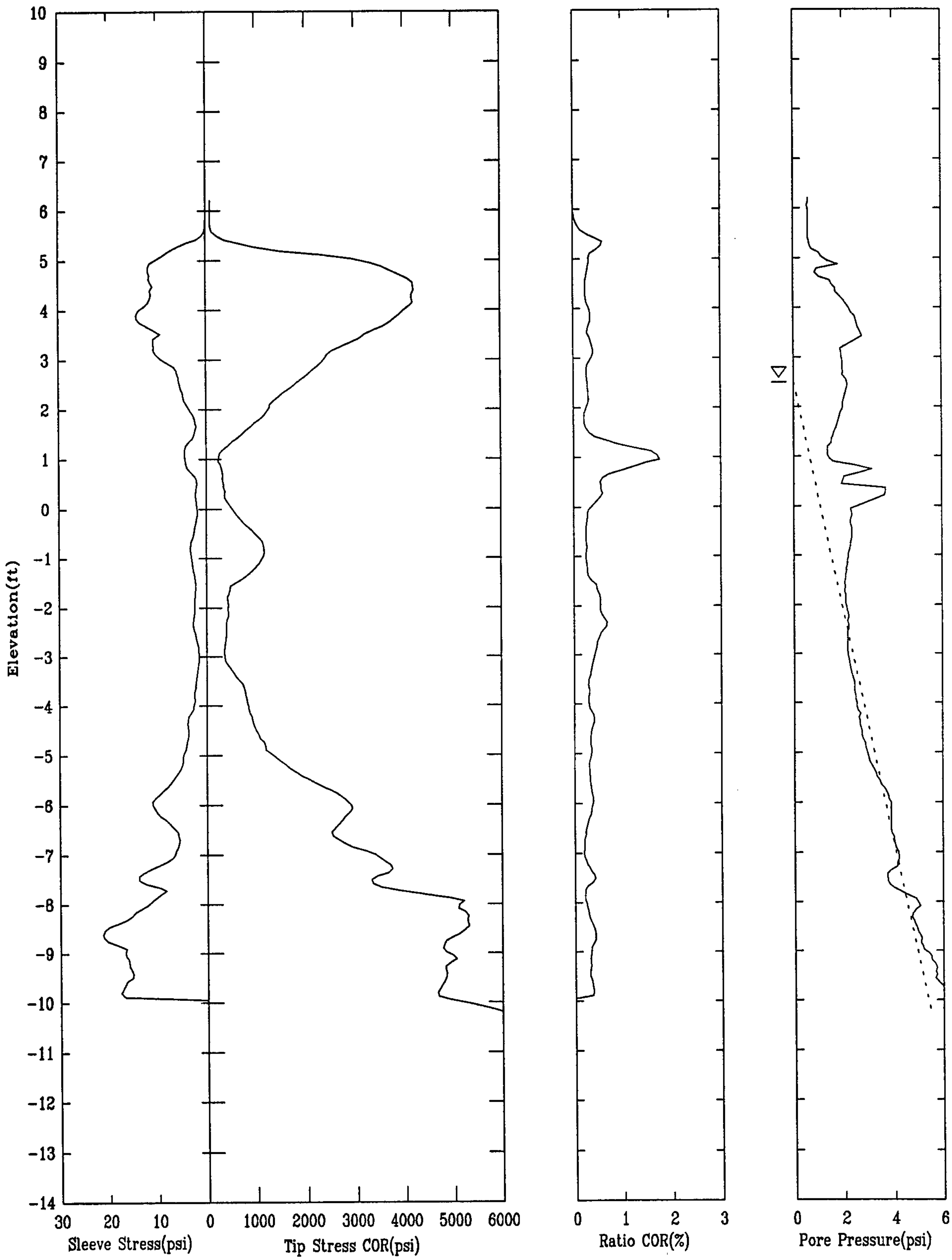

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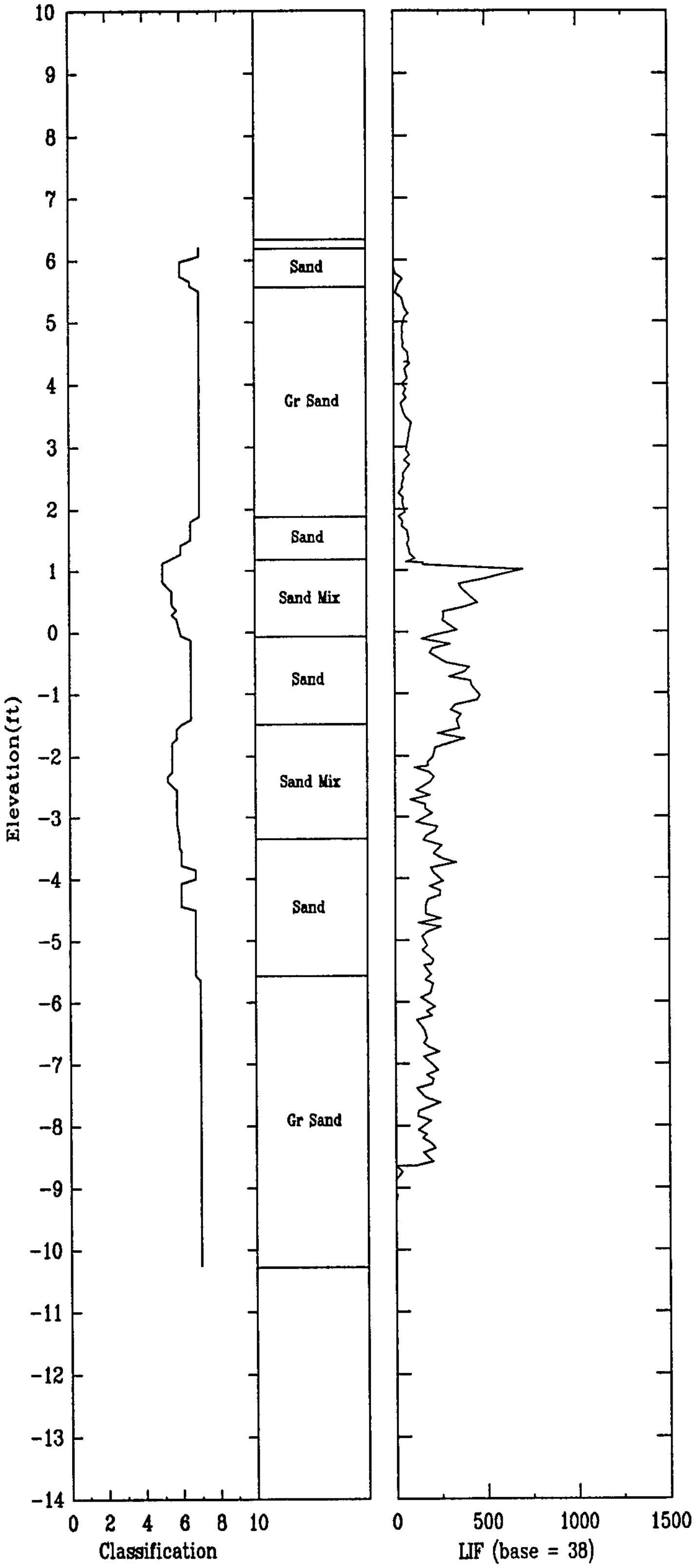

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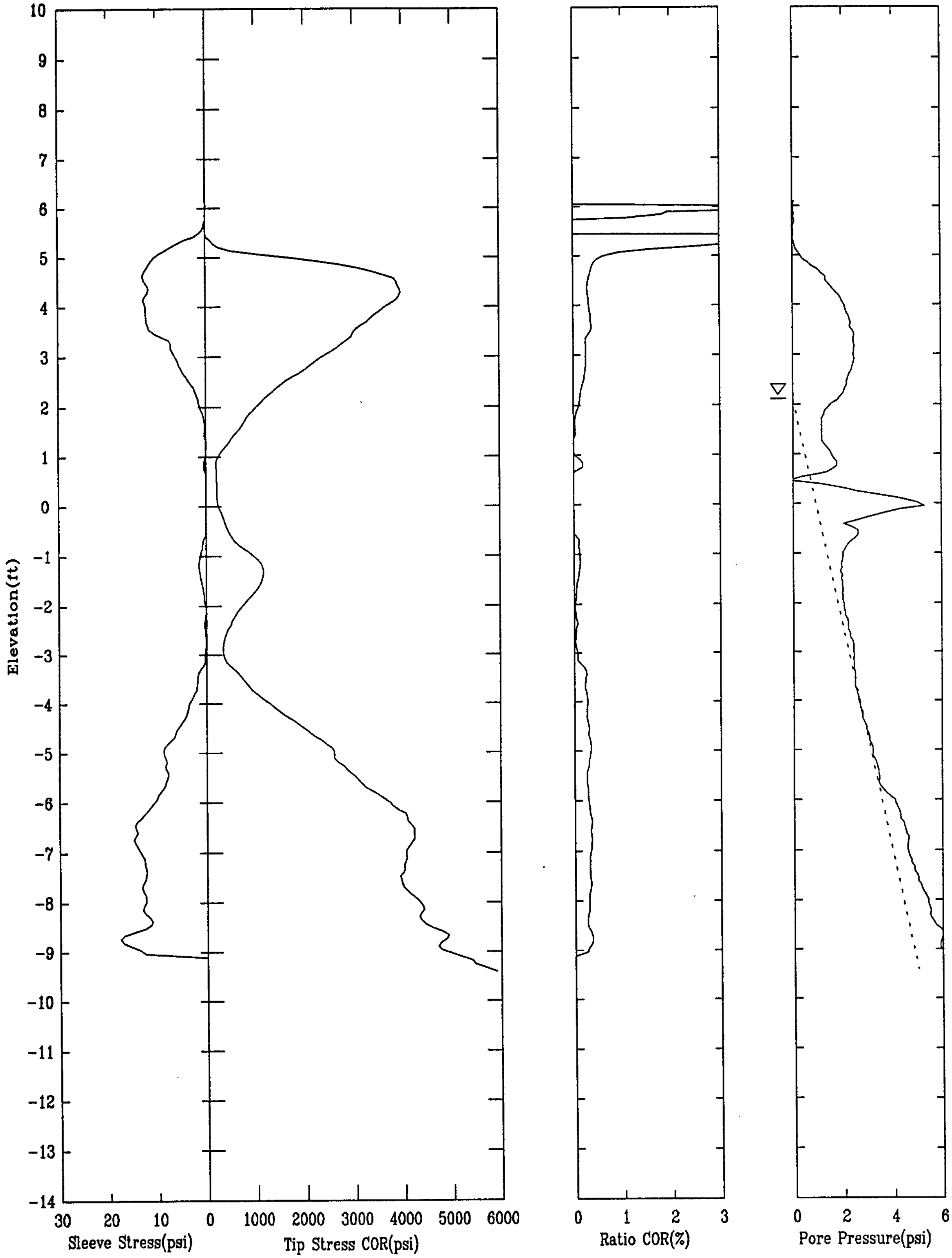

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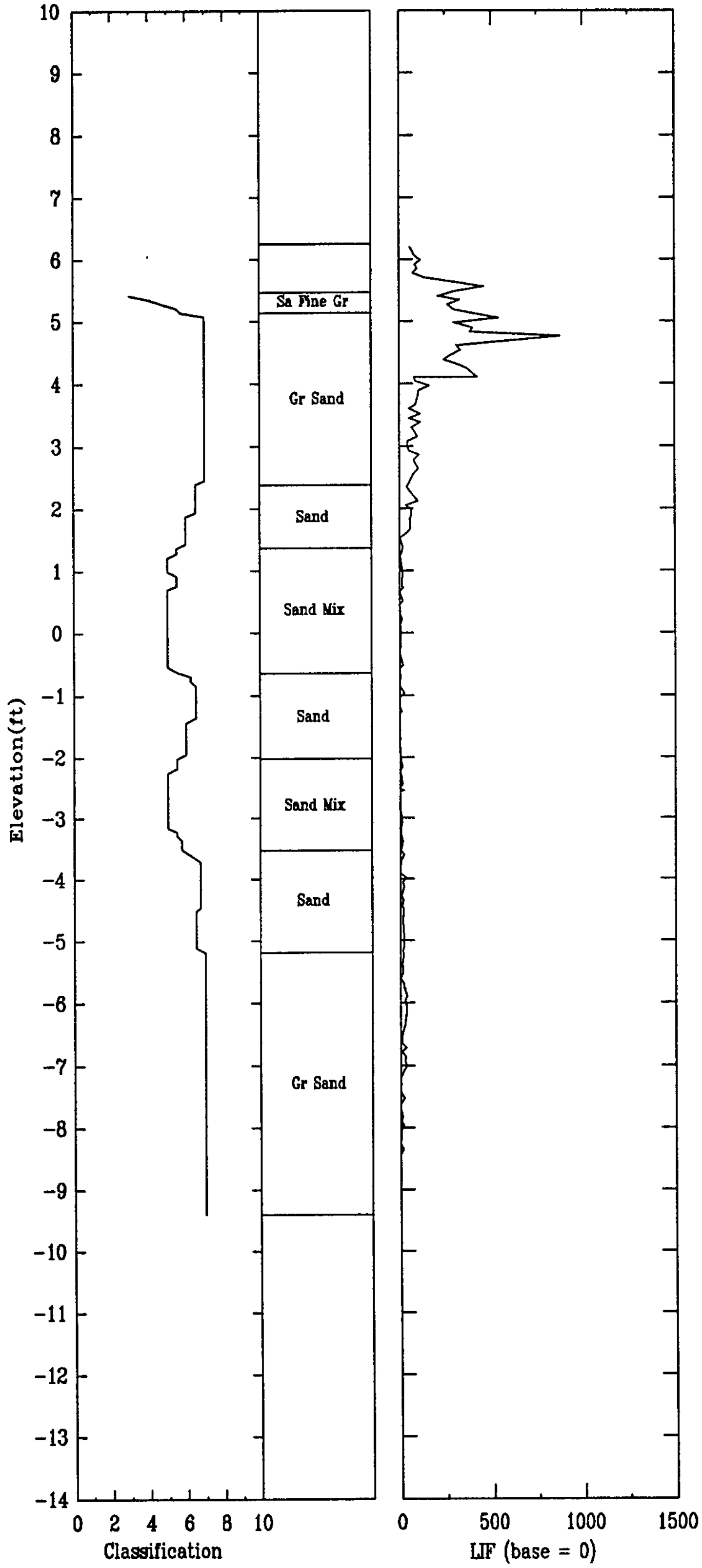

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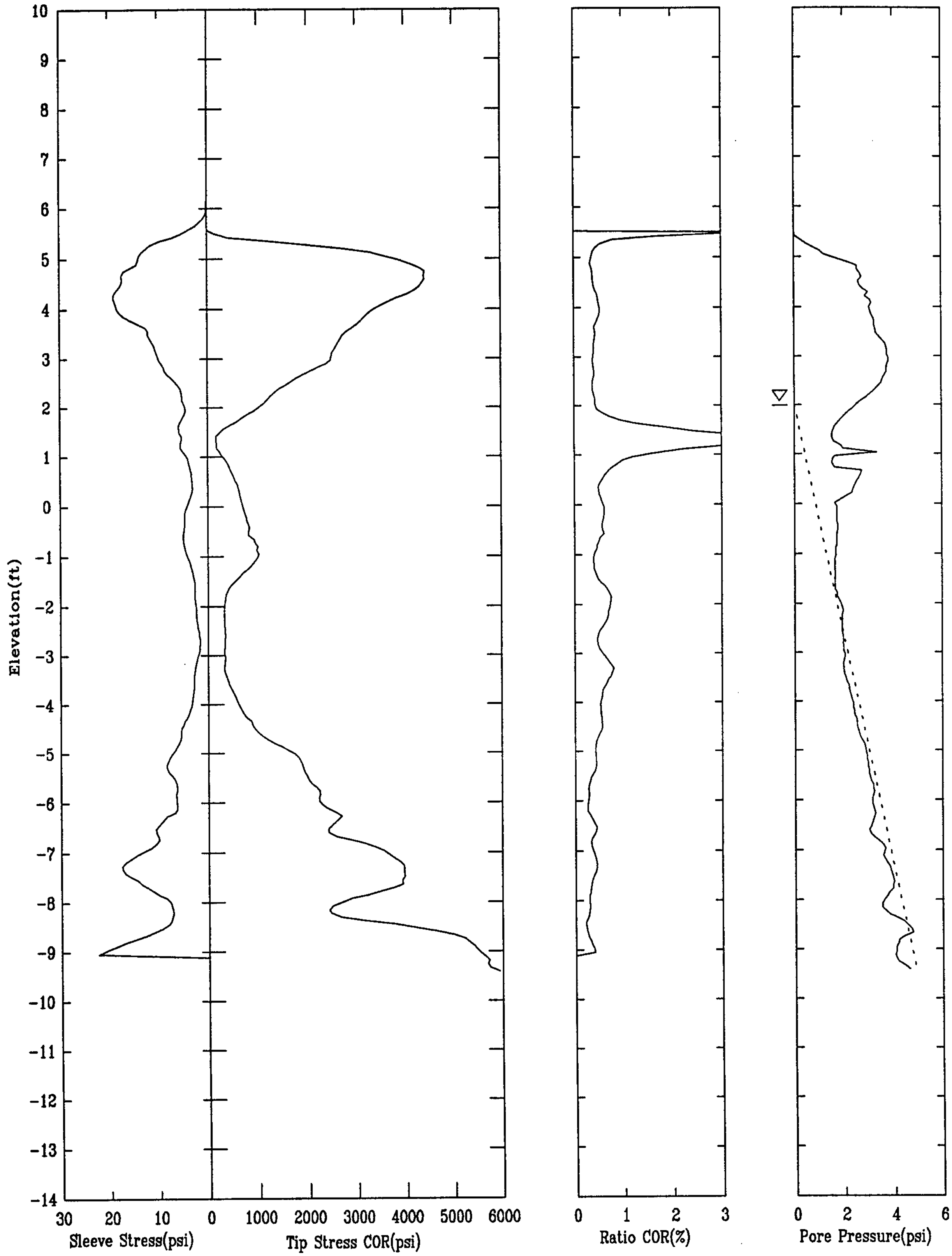

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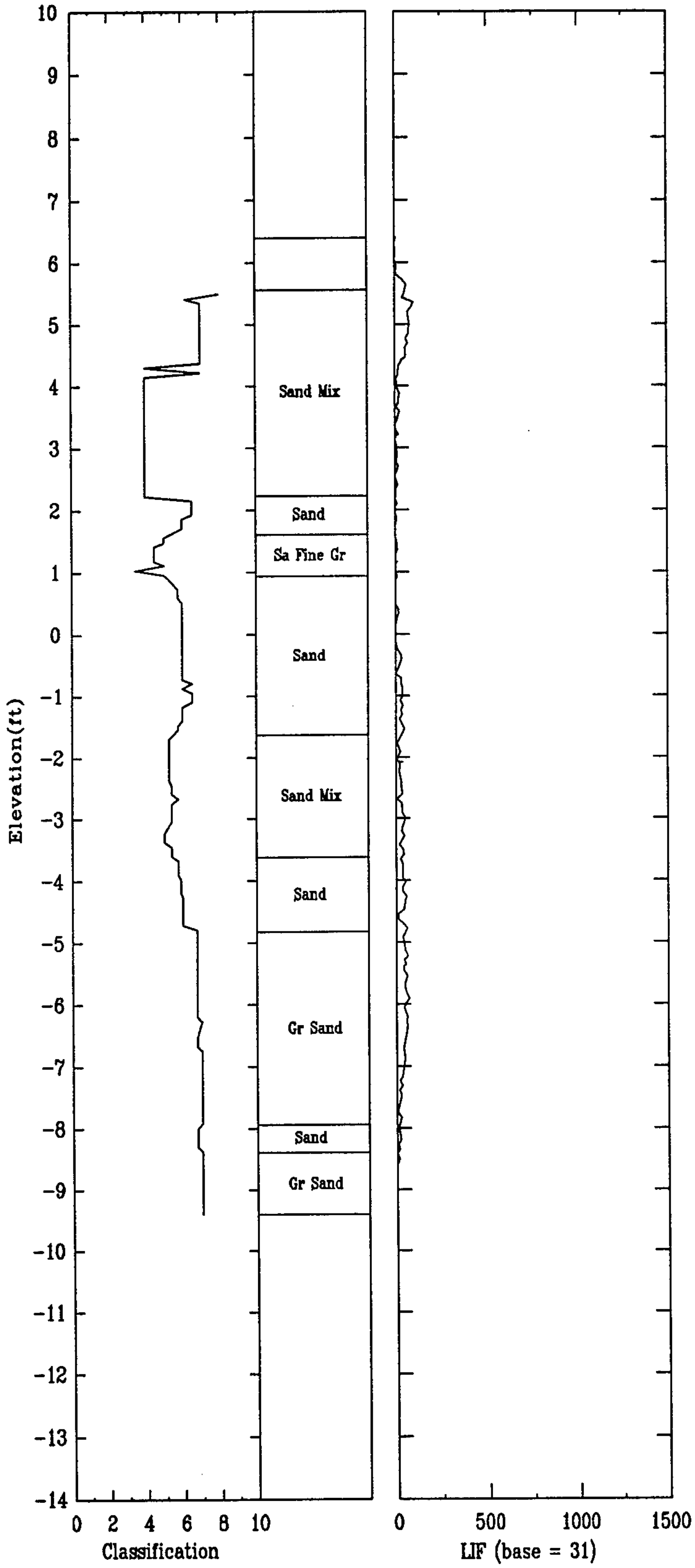

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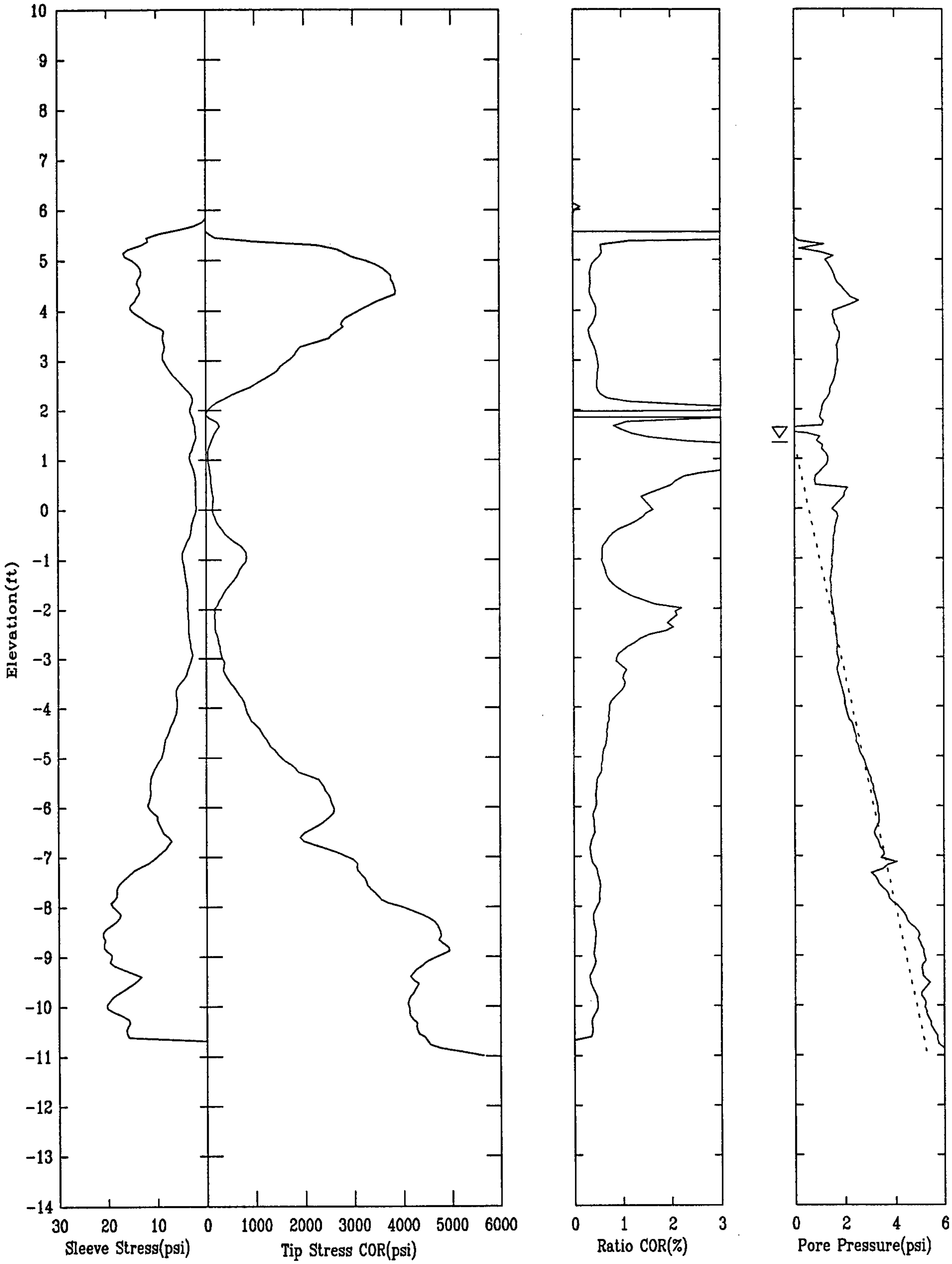
North 442 East 223 Elevation 6.41



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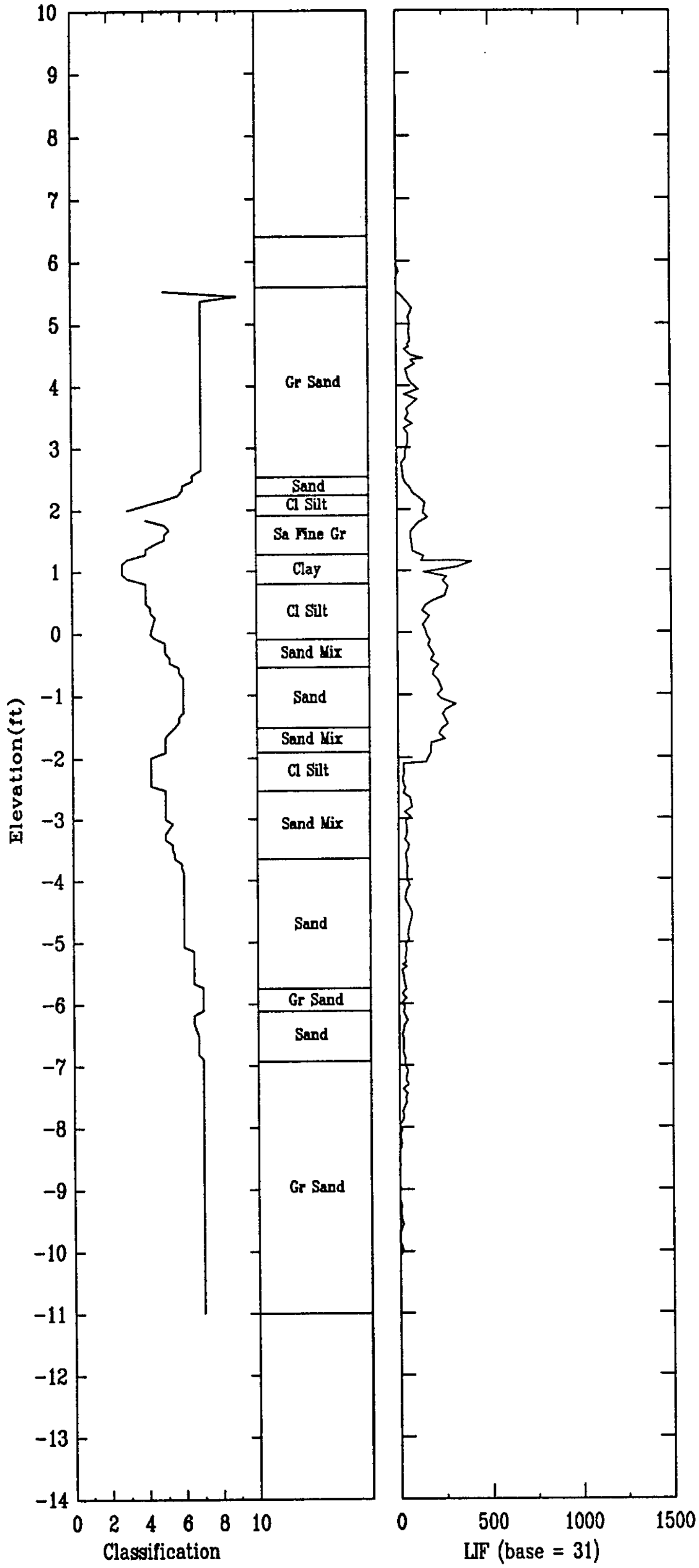

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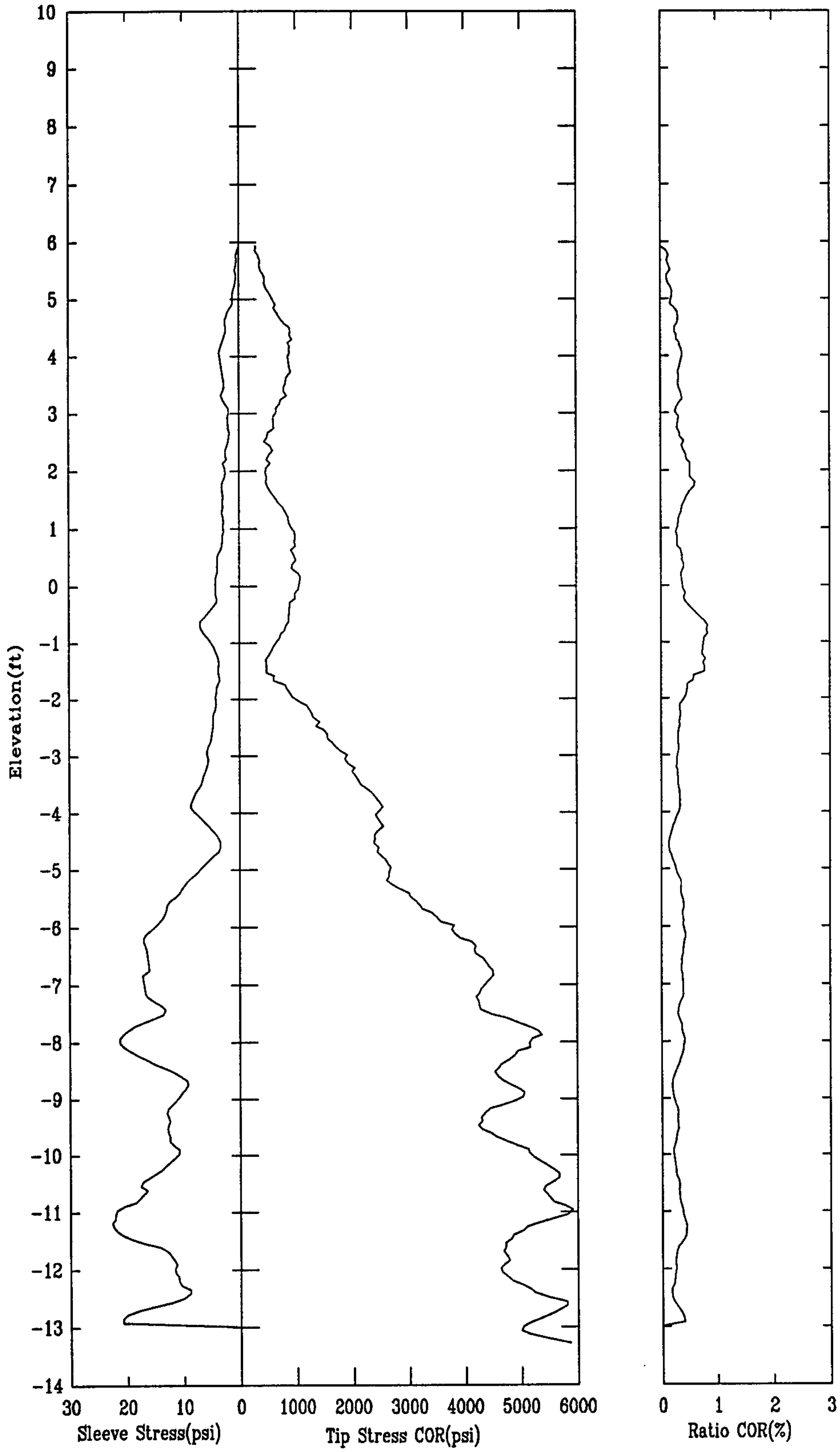
North 427 East 300 Elevation 6.14



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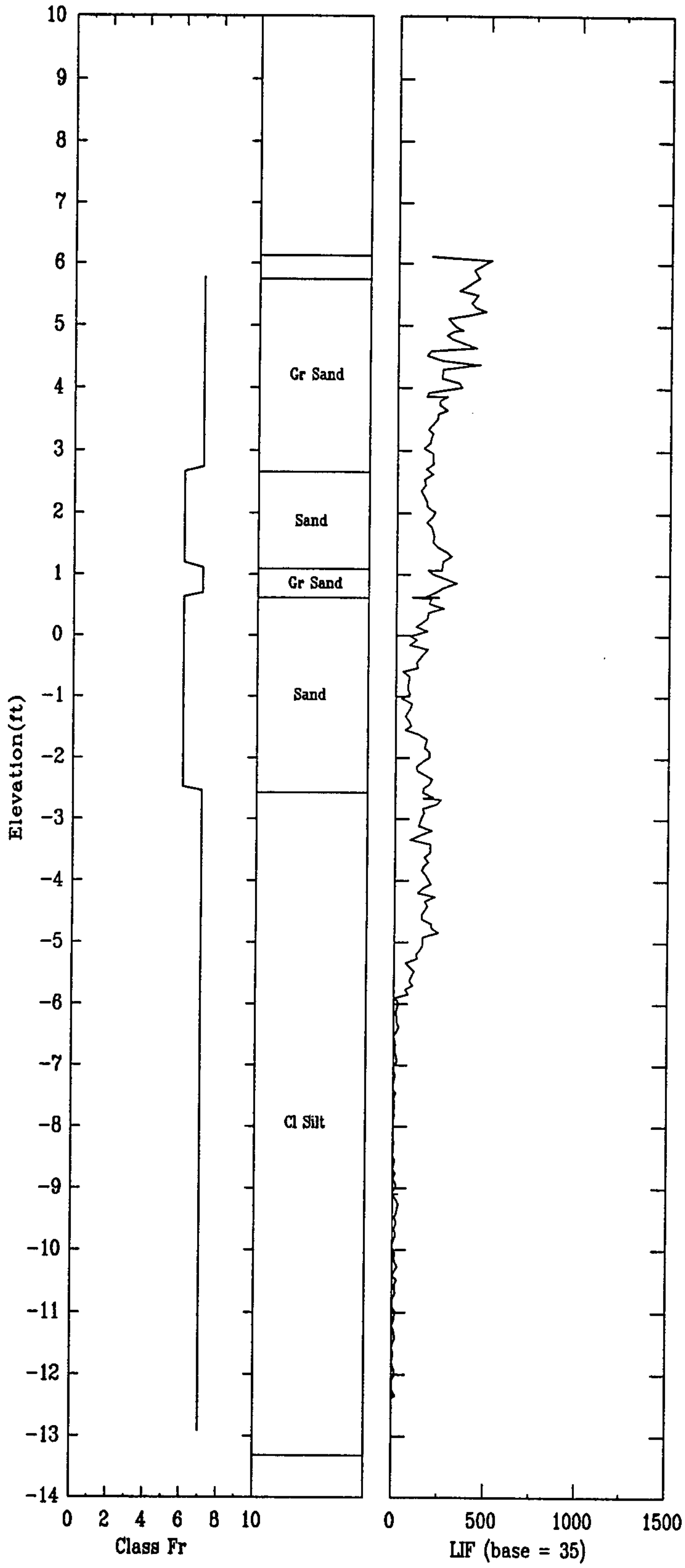

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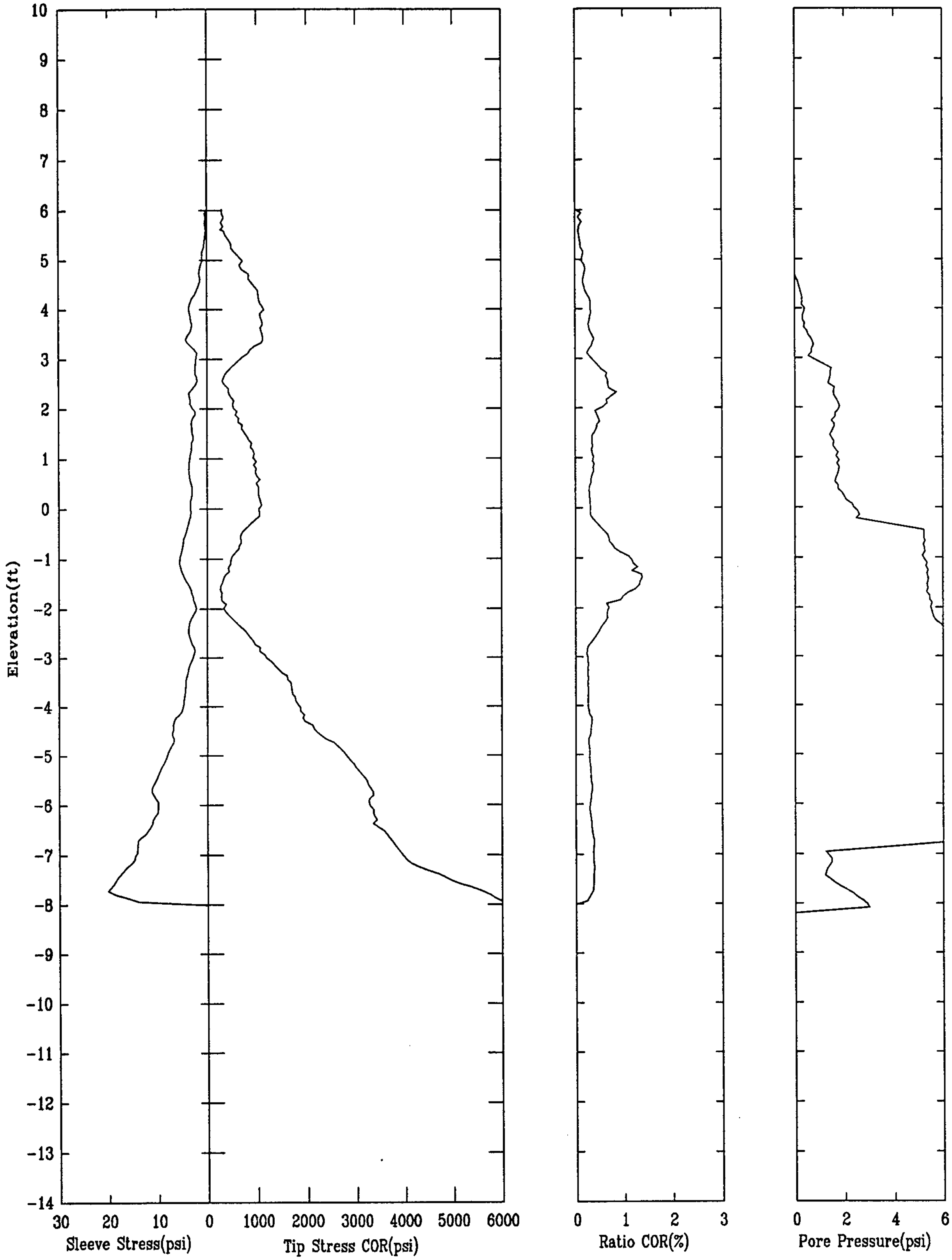
North 463 East 316 Elevation 6.21



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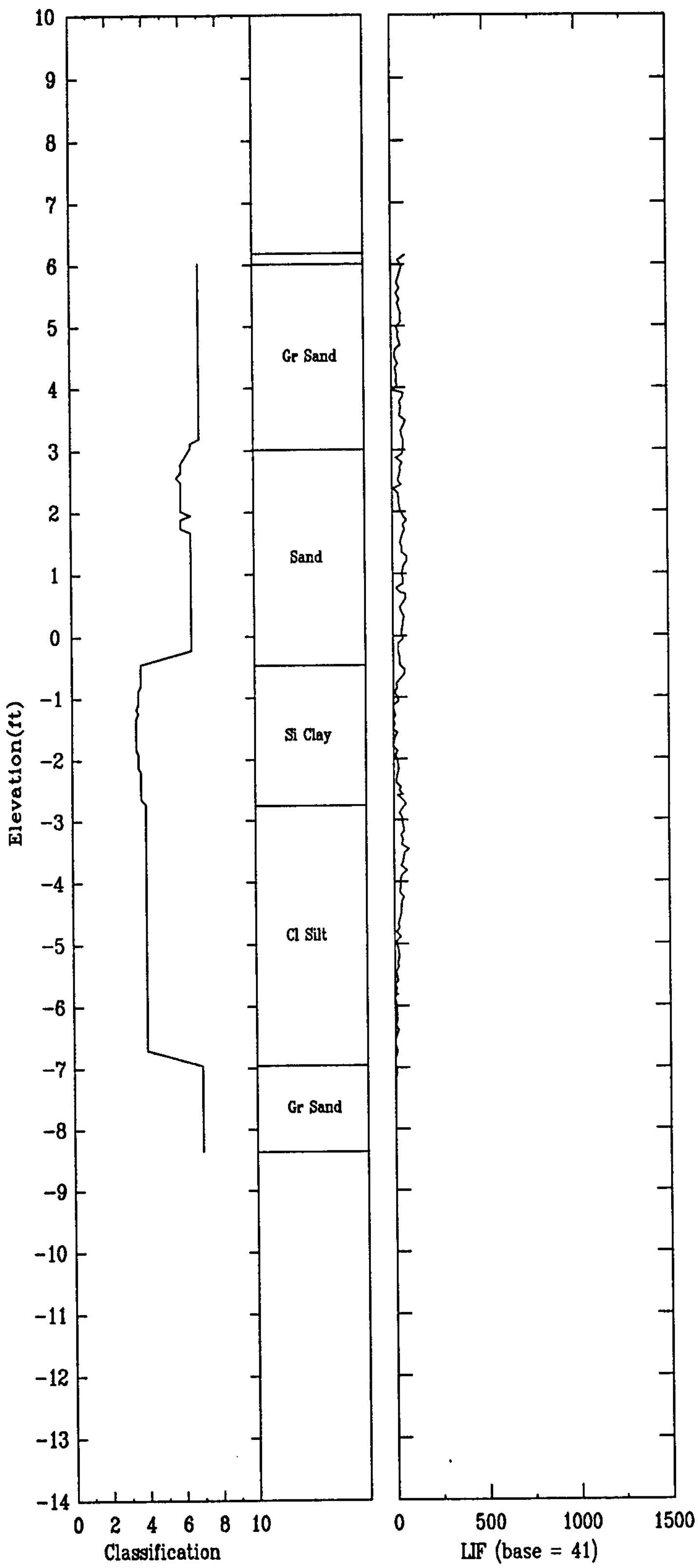
North 463 East 316 Elevation 6.21



CPT-86-22-LIF APPLIED RESEARCH ASSOCIATES, INC. 03/24/94

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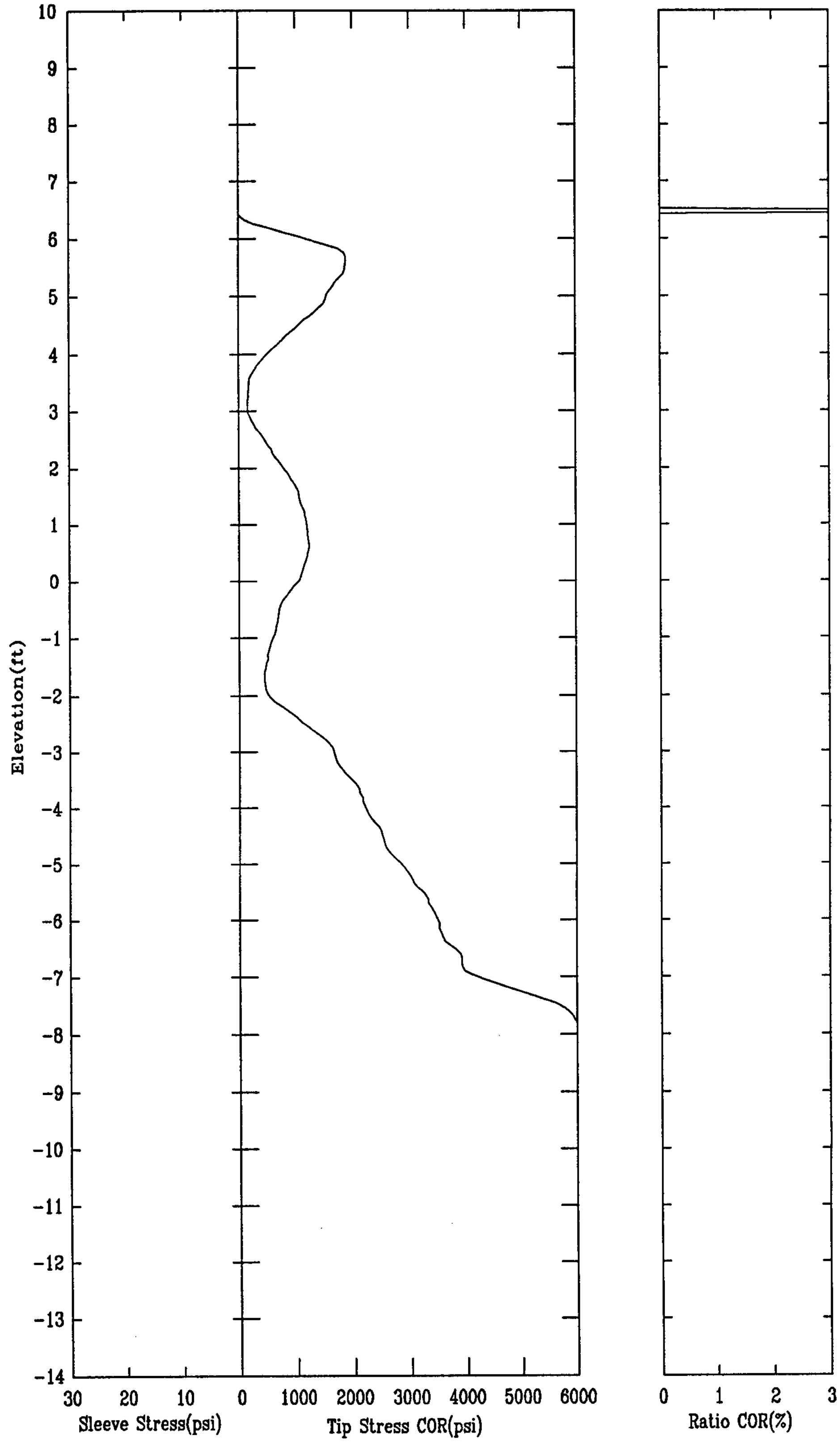

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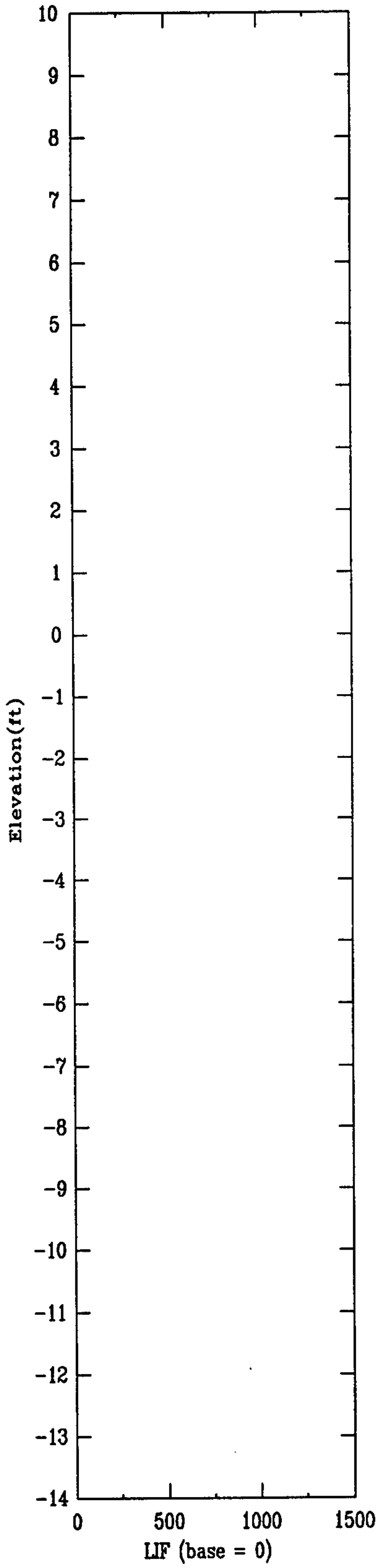
North 362 East 328 Elevation 6.75



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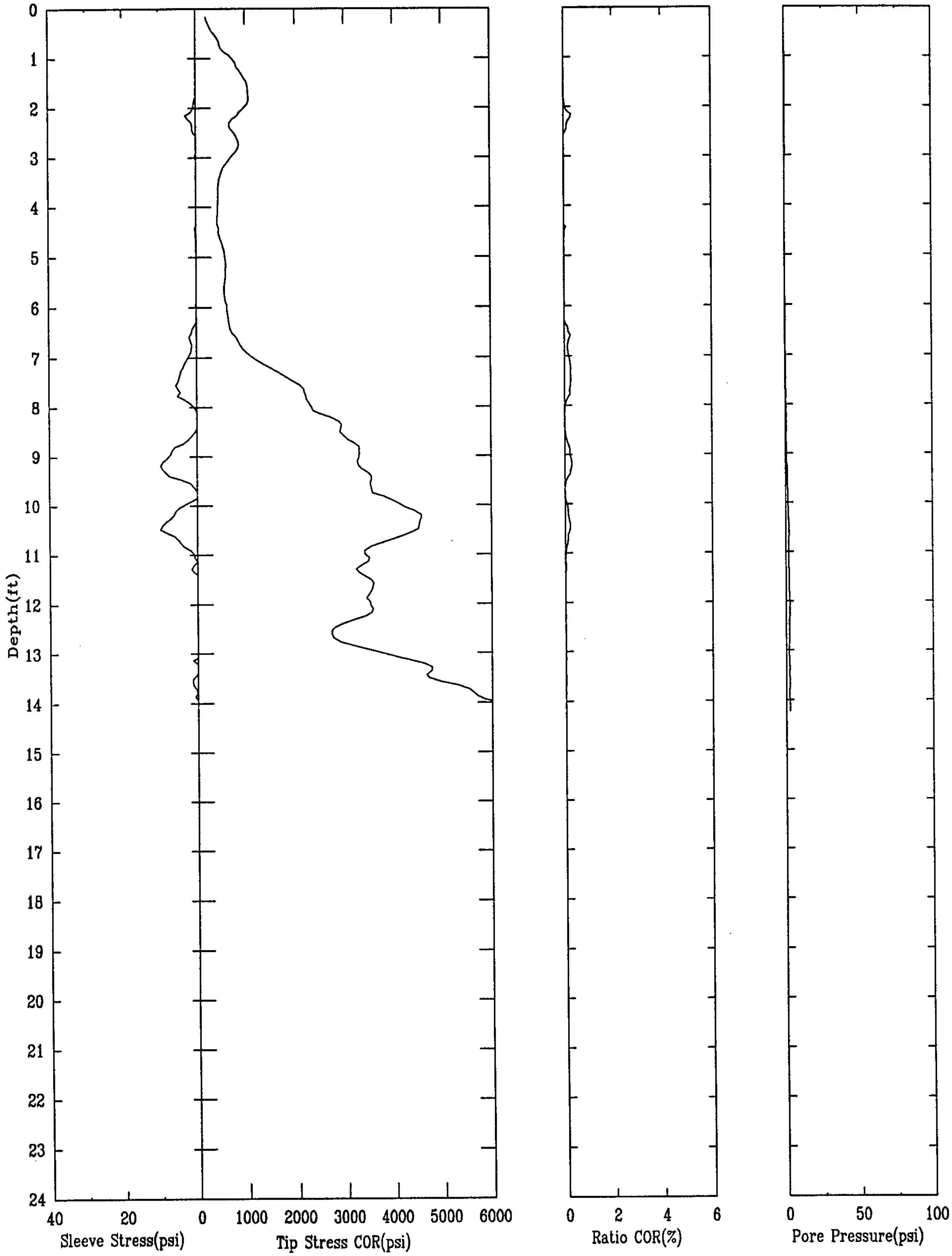
CCAFB



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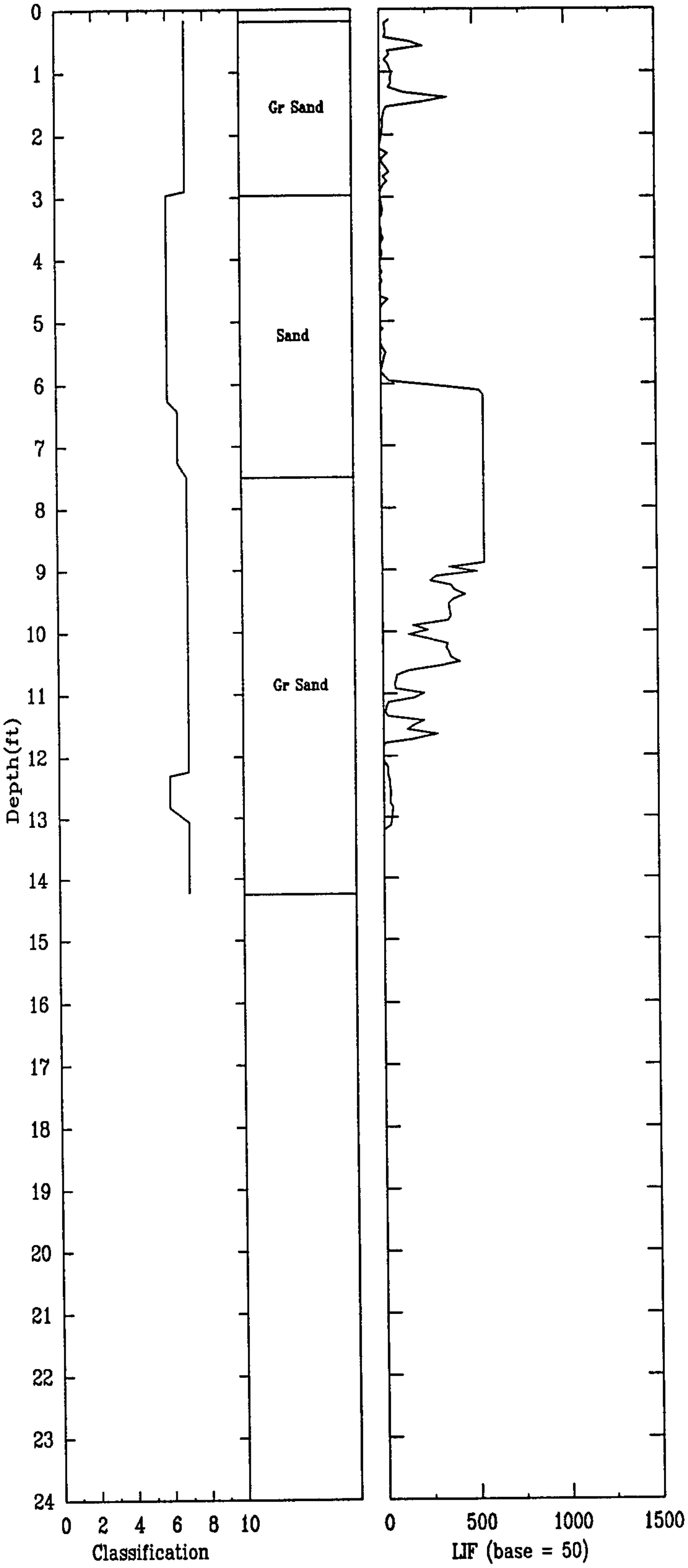

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11
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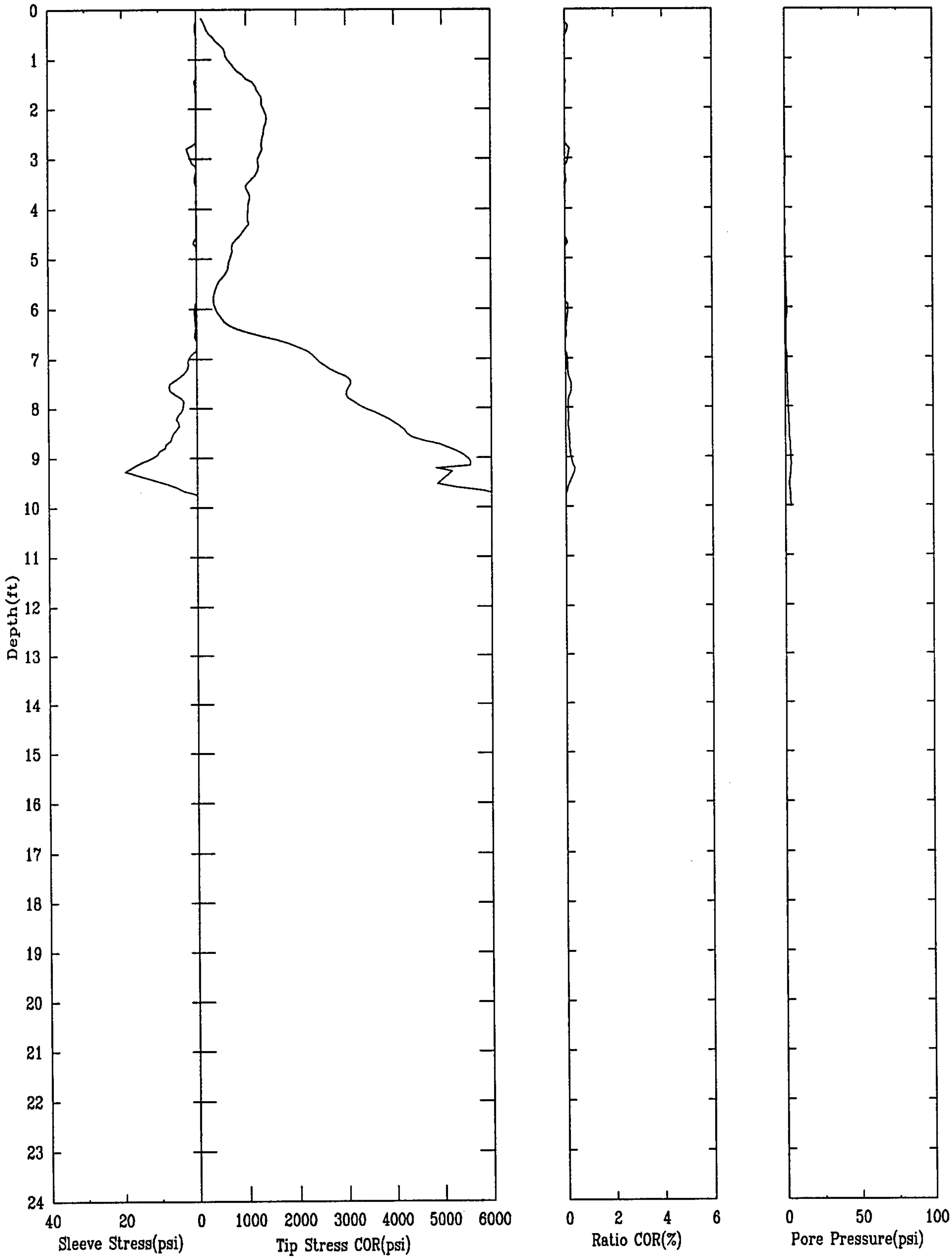
14
15
16
17
18
19
20
21
22
23
24
Depth(ft)
0 2 4 6 8 10
Classification
Gr Sand
Sand
Gr Sand
0 500 1000 1500
LIF (base = 50)

CCAFB-02 APPLIED RESEARCH ASSOCIATES, INC. 03/28/94

CCAFB



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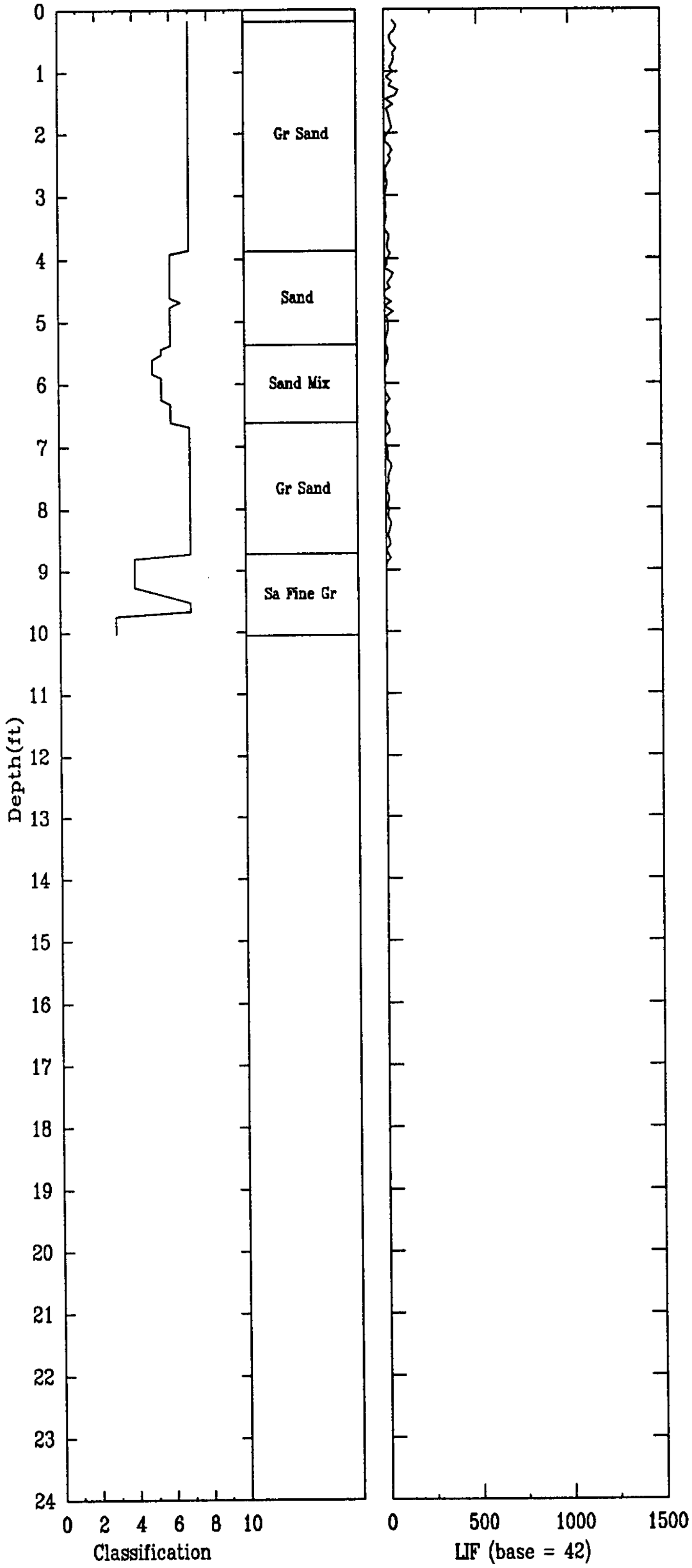
CCAFB



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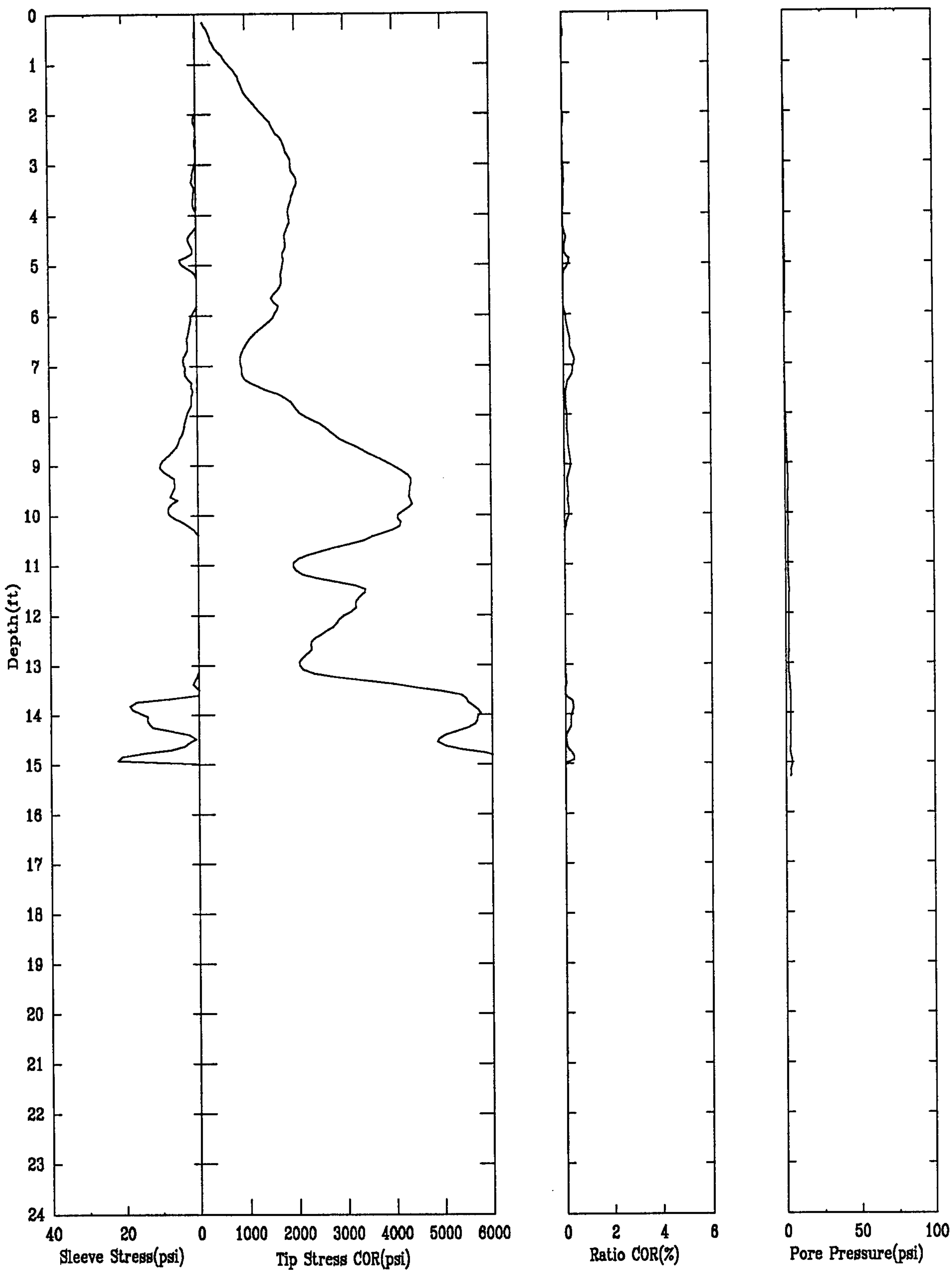

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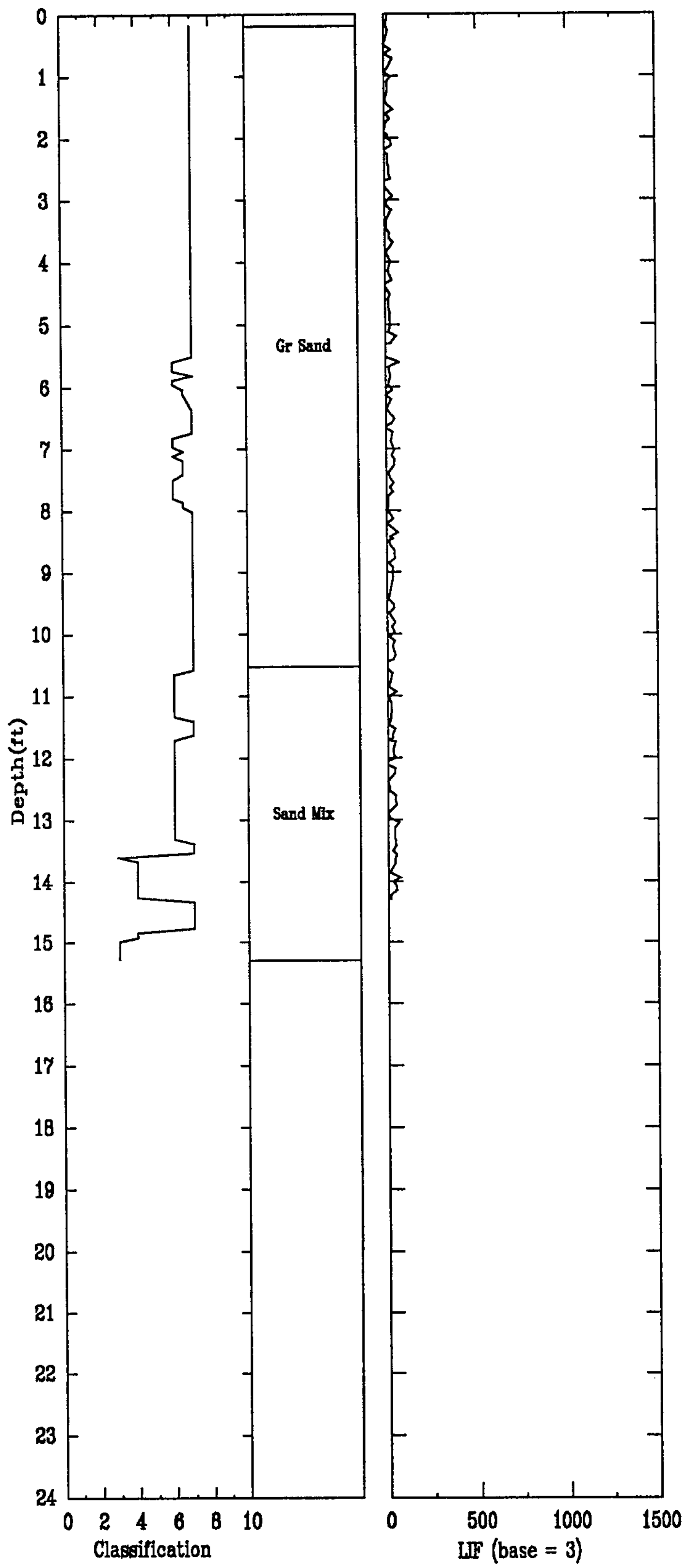

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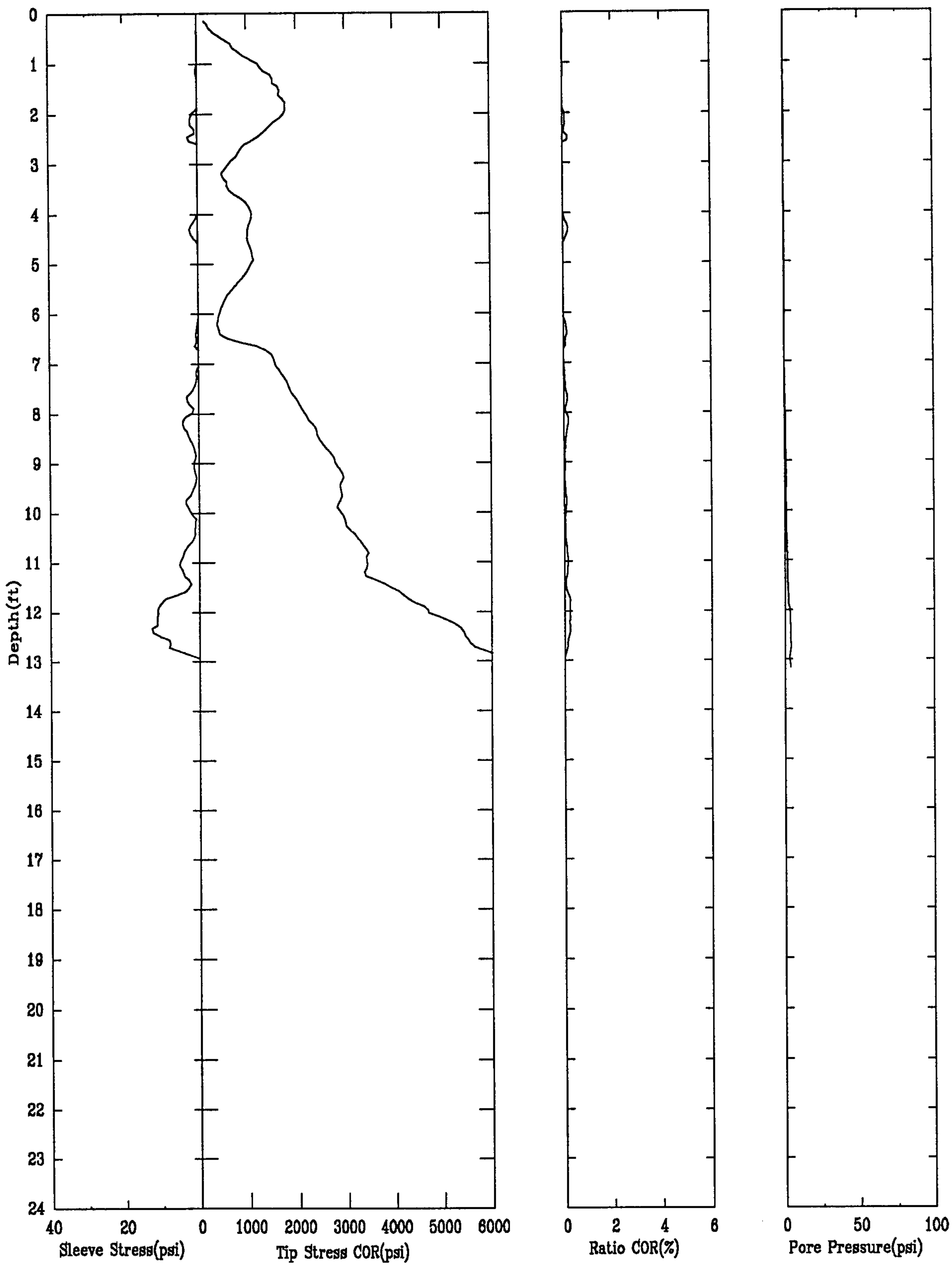
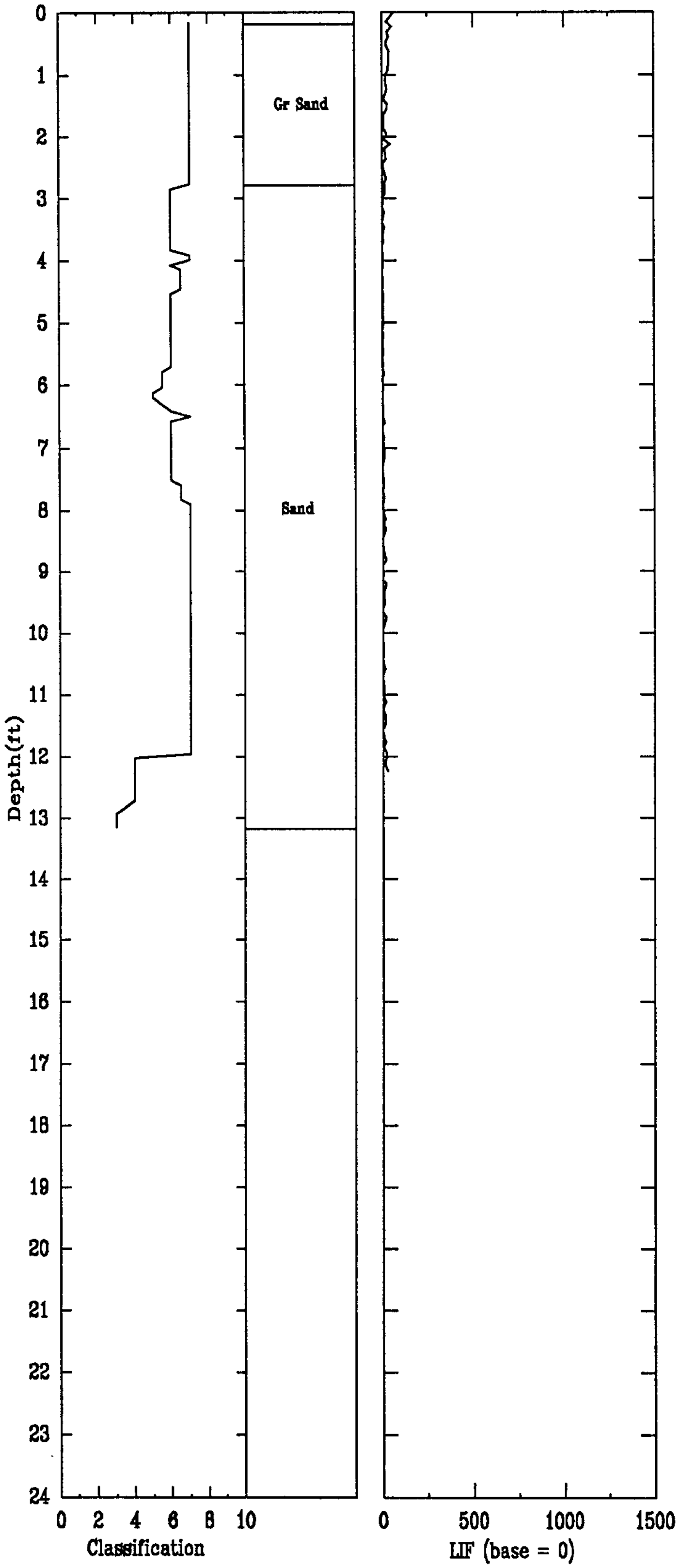
CCAFB




Depth(ft)
0
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2
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4
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19
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21
22
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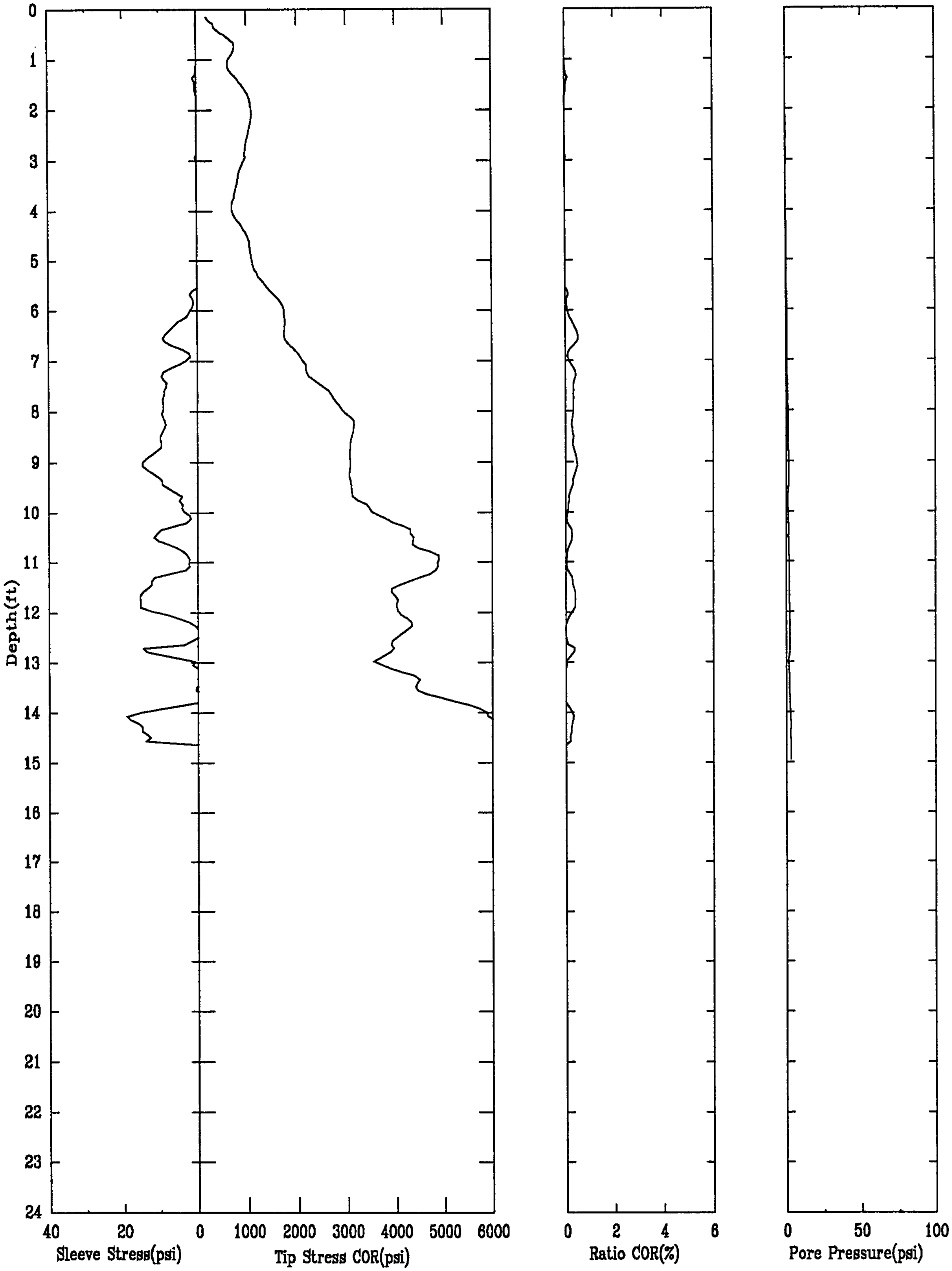
CCAFB–05 APPLIED RESEARCH ASSOCIATES, INC. 03/28/94

CCAFB



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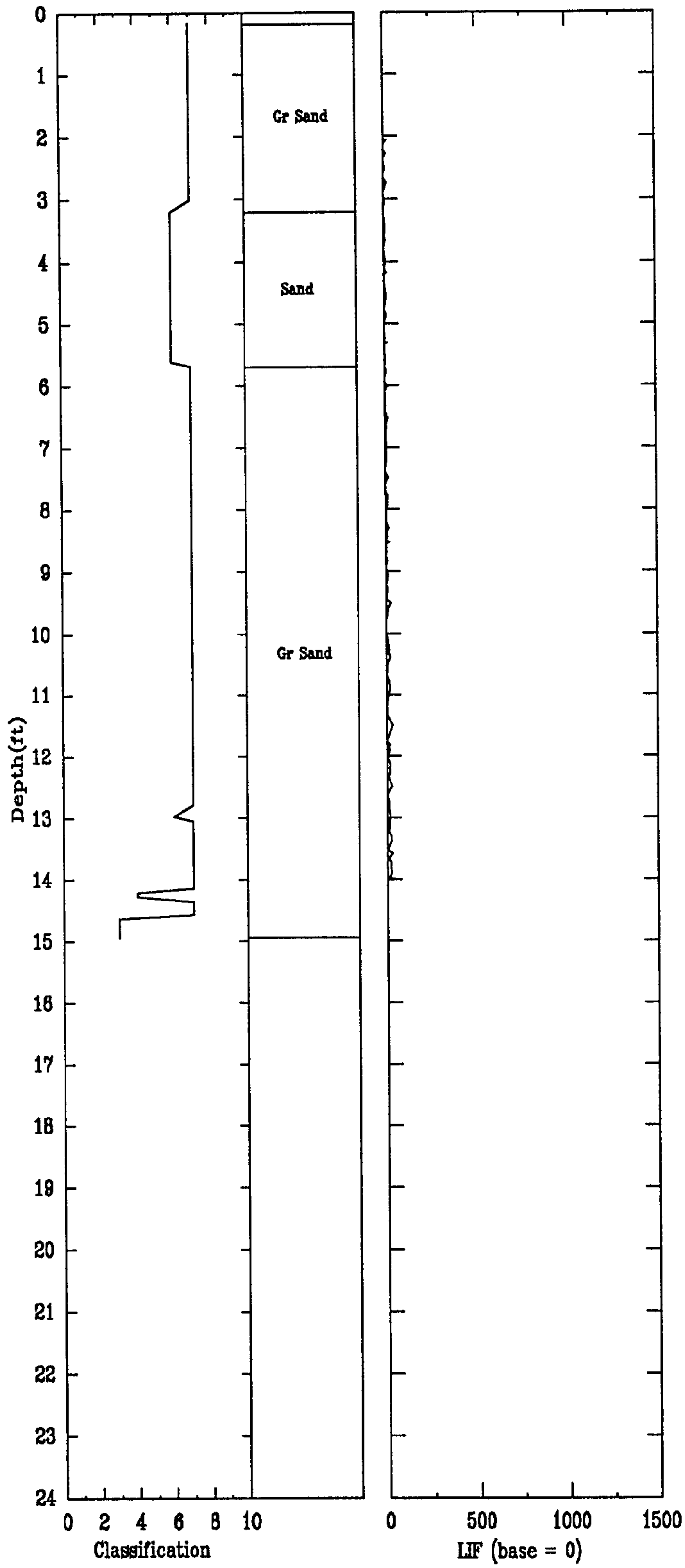

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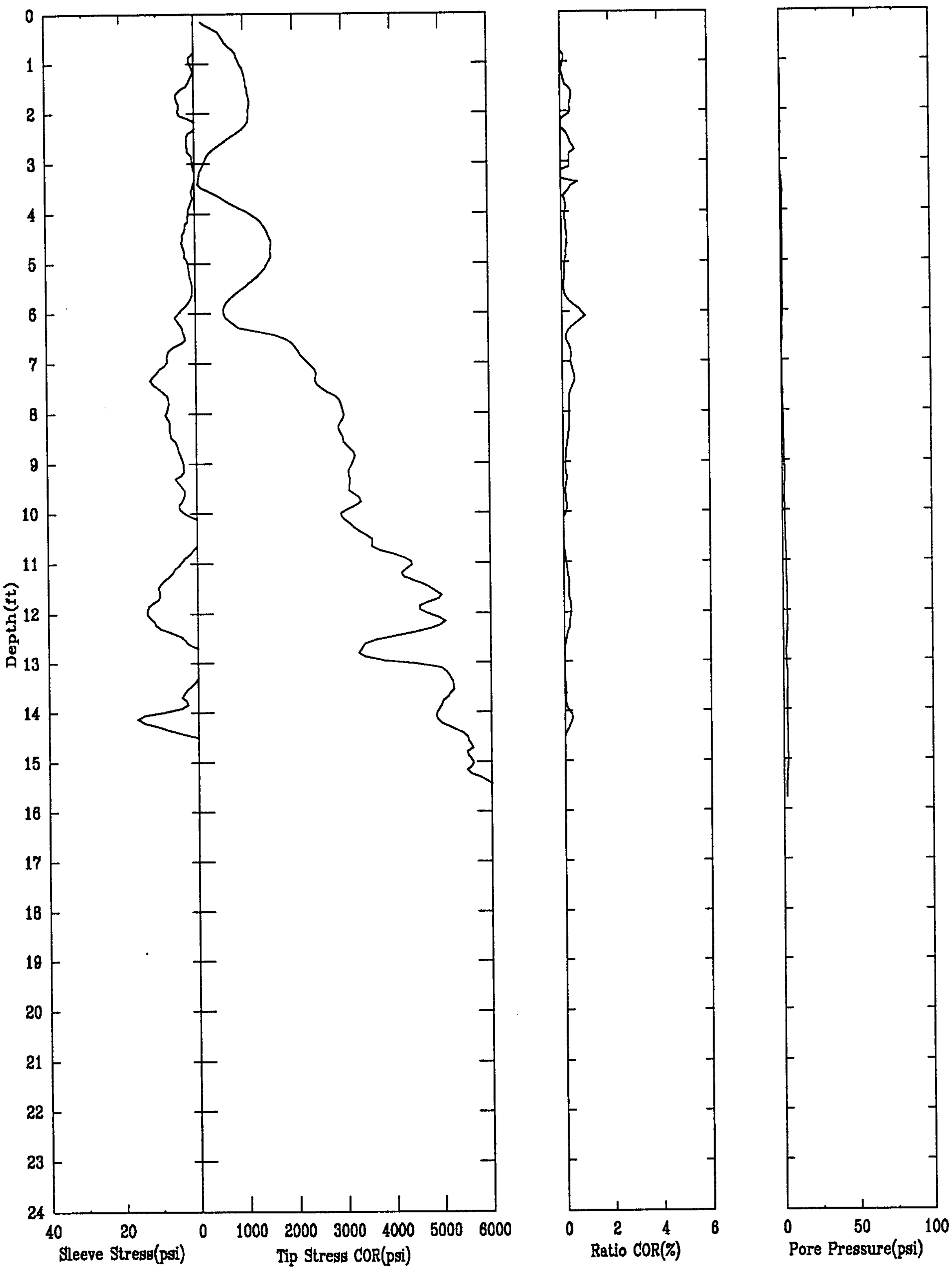

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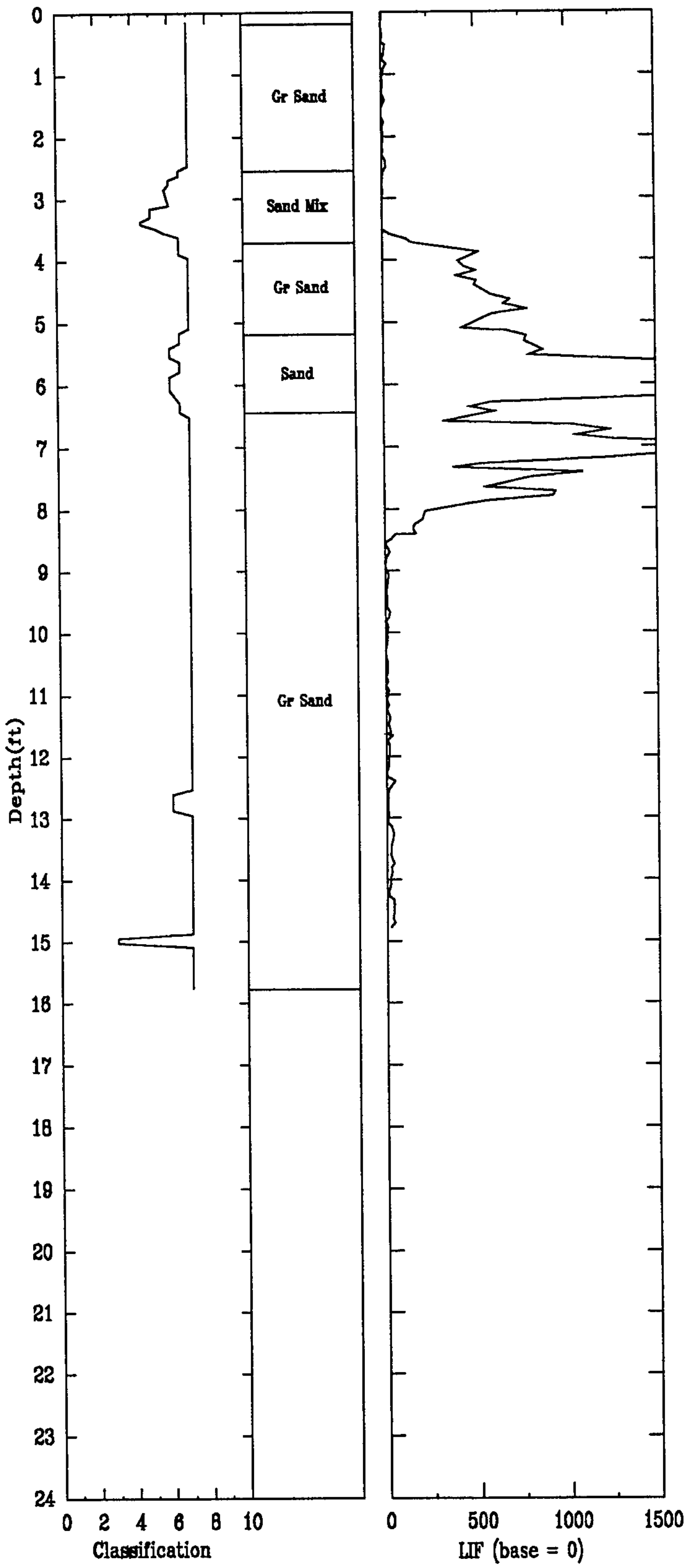

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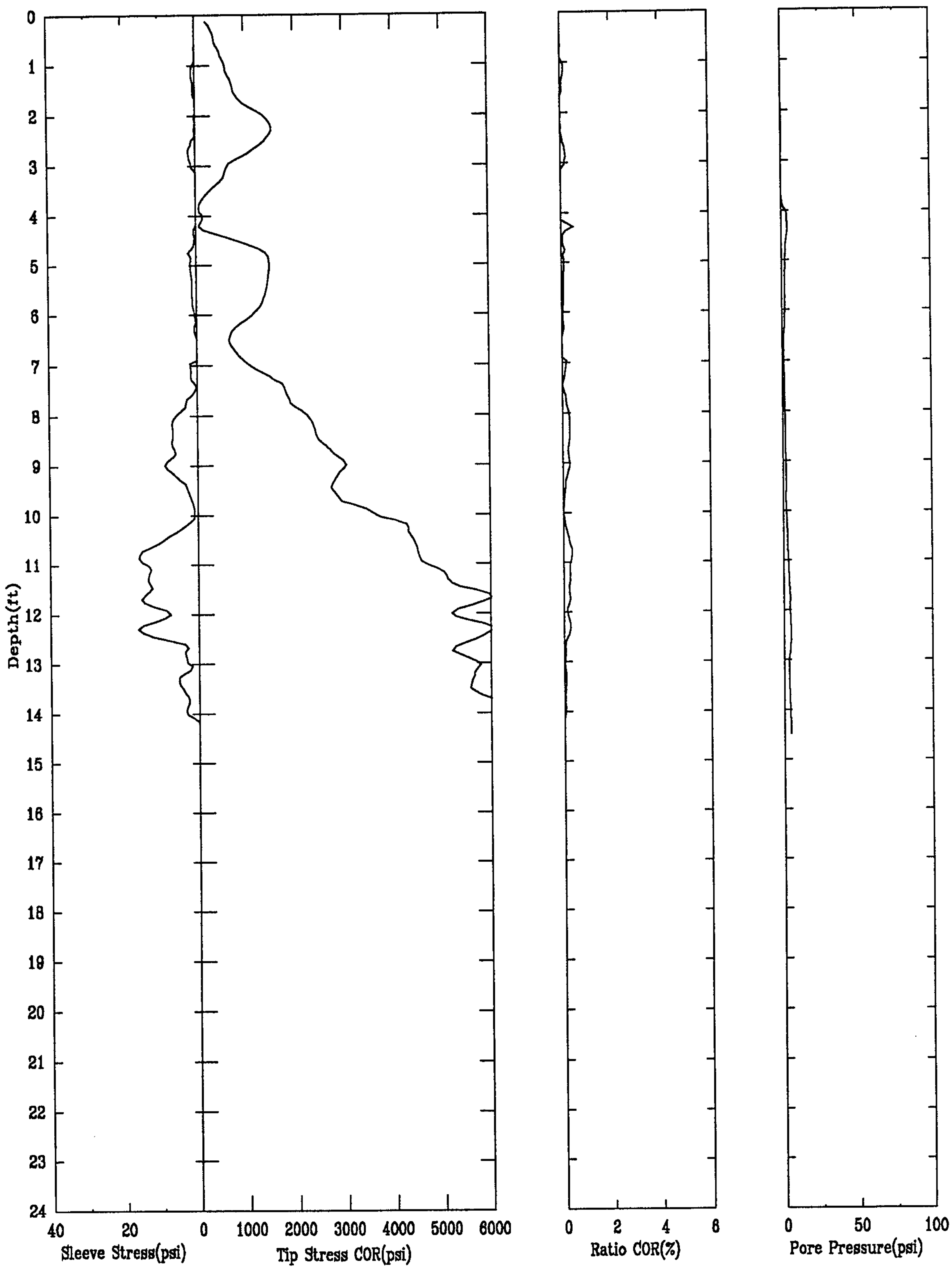

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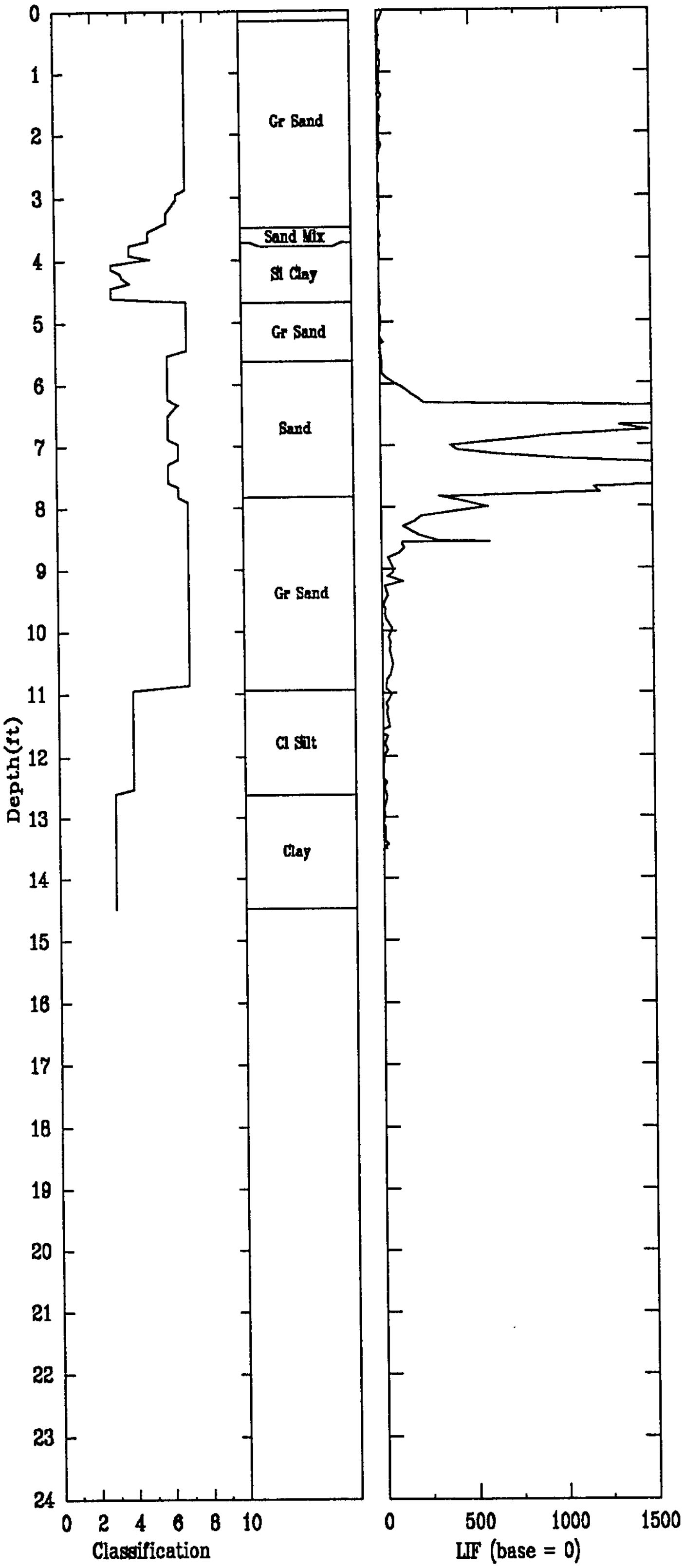

CCAFB--08 APPLIED RESEARCH ASSOCIATES, INC. 03/28/94

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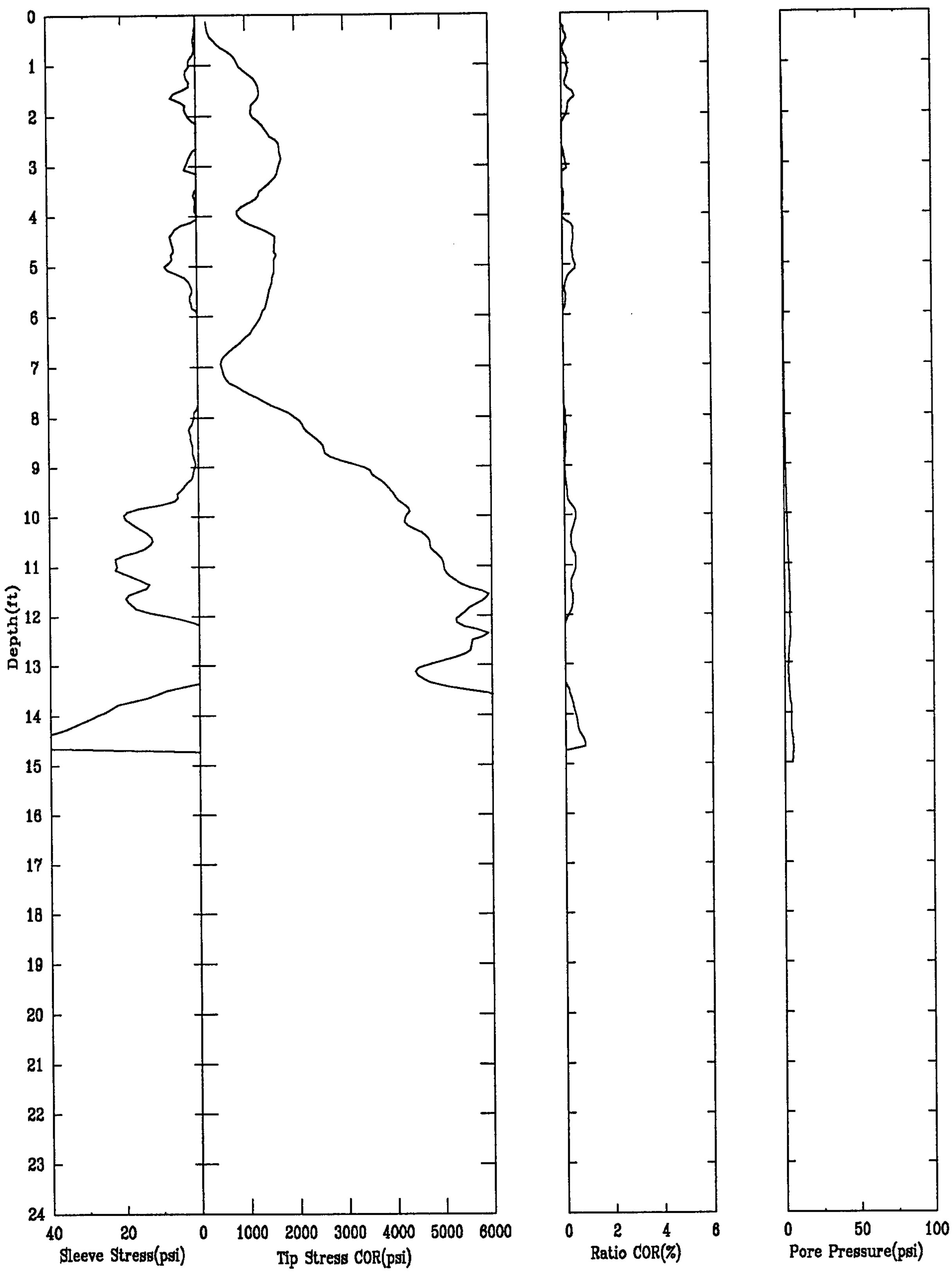

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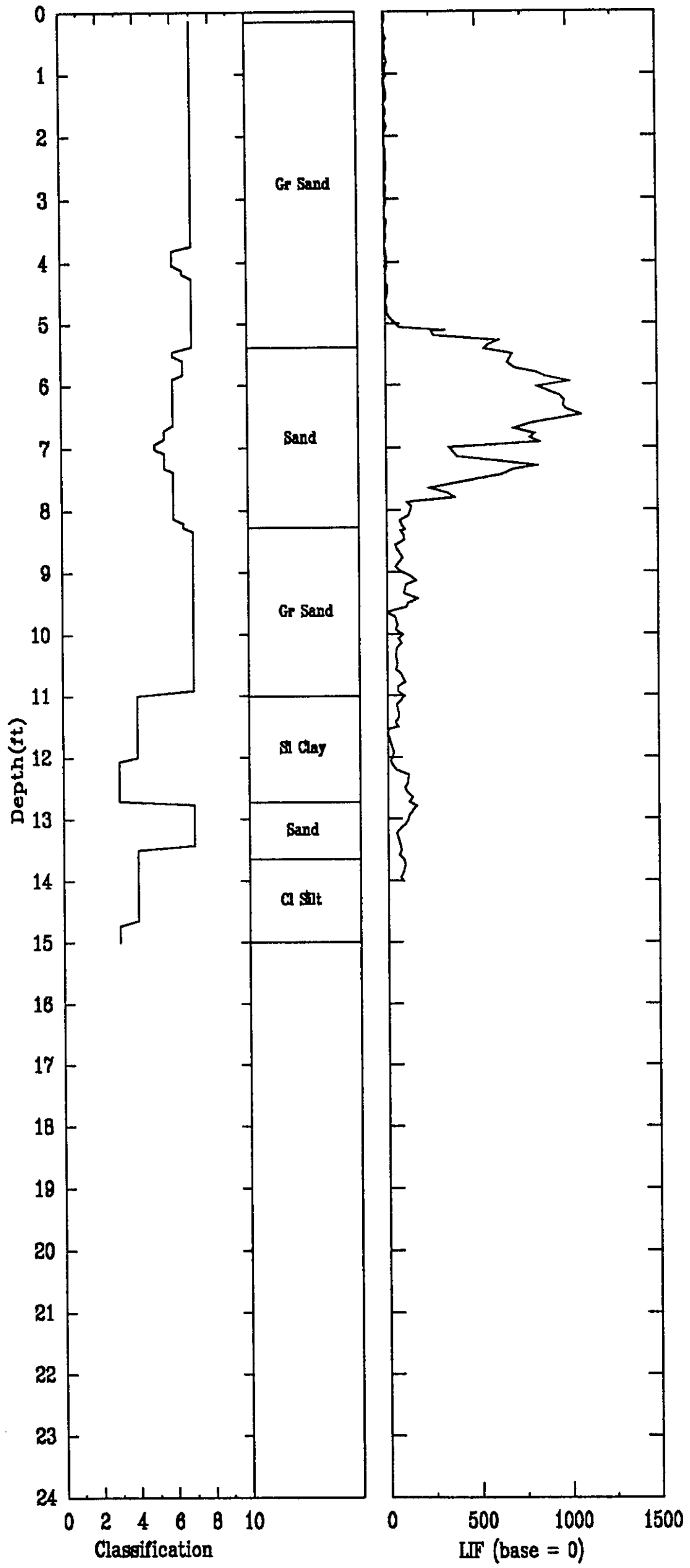

CCAFB-09 APPLIED RESEARCH ASSOCIATES, INC. 03/28/94

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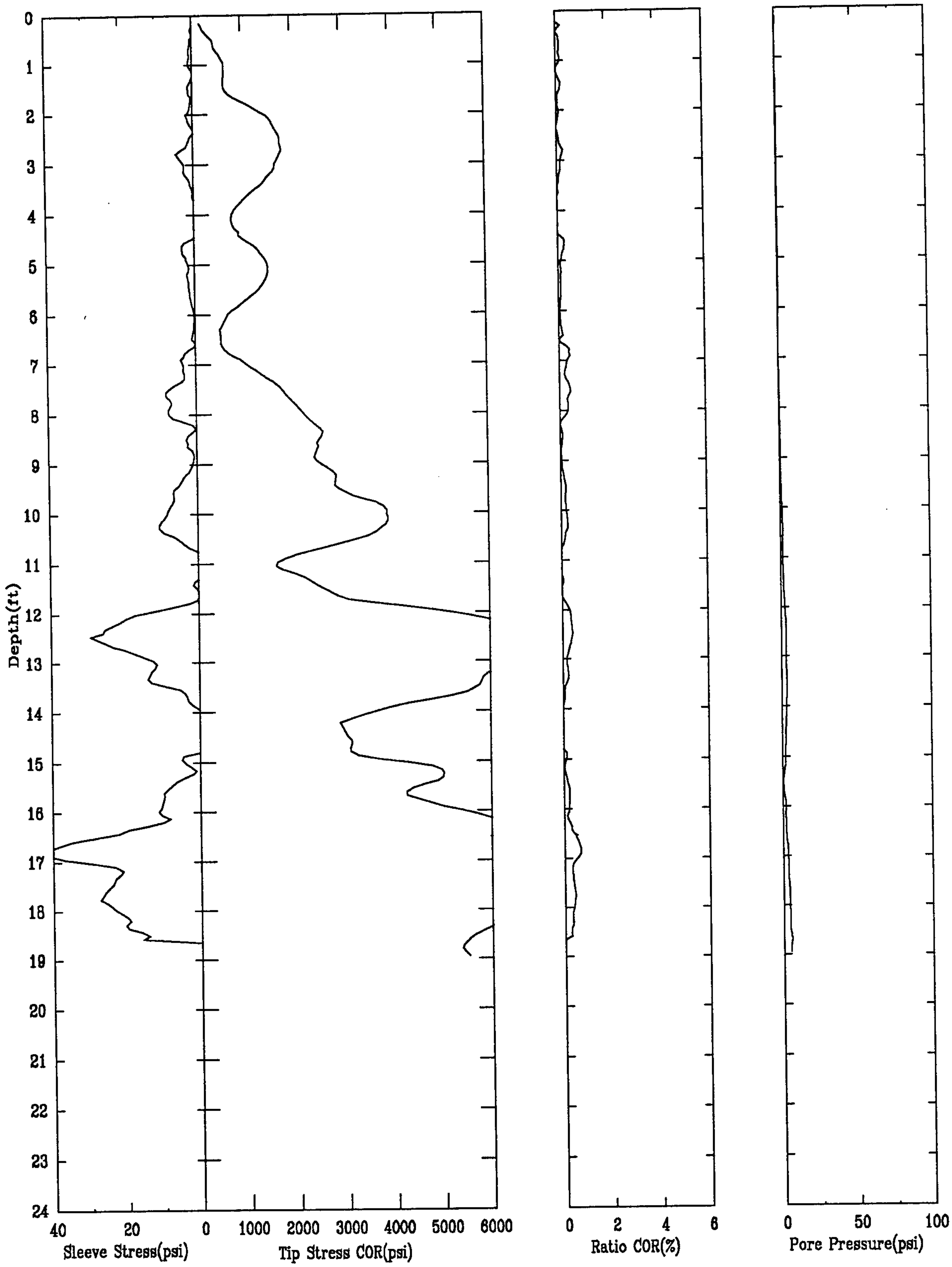

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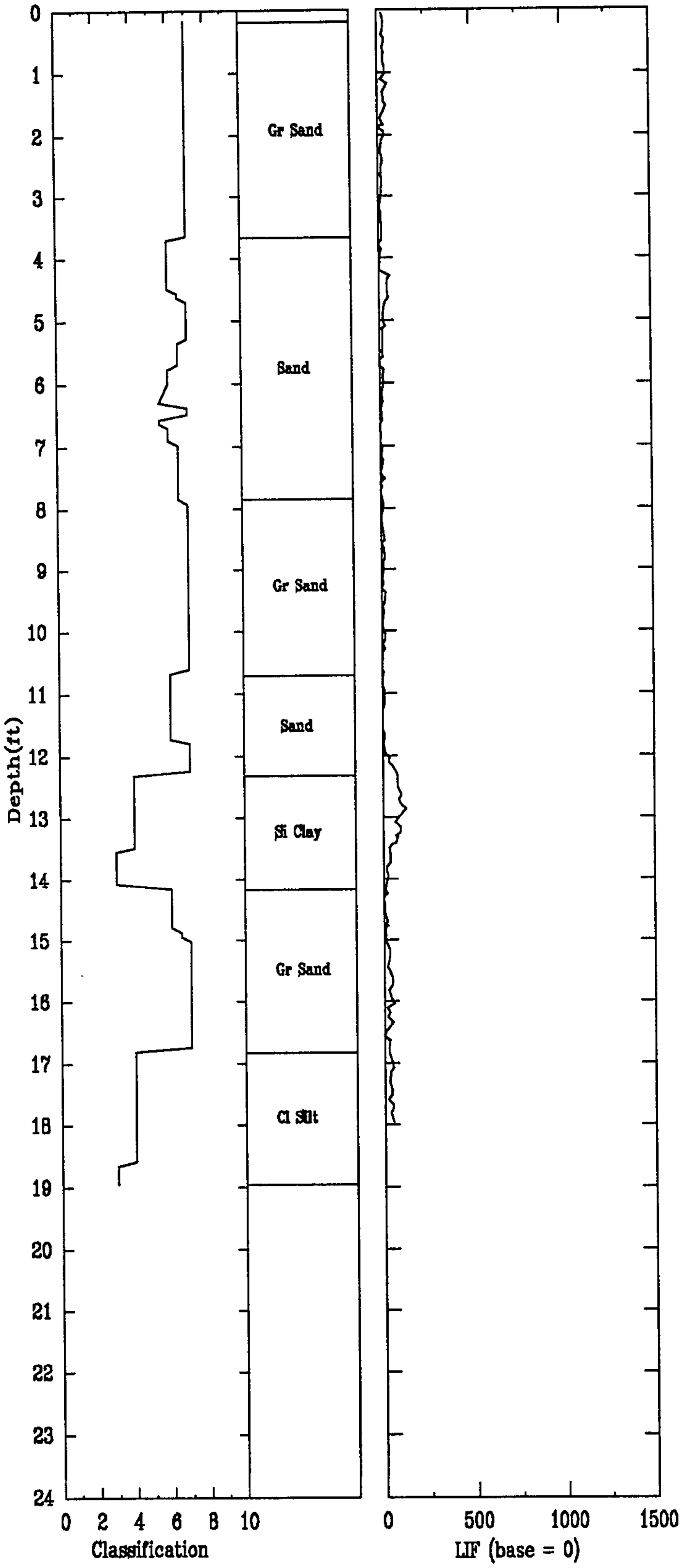

CCAFB-10 APPLIED RESEARCH ASSOCIATES, INC. 03/28/94

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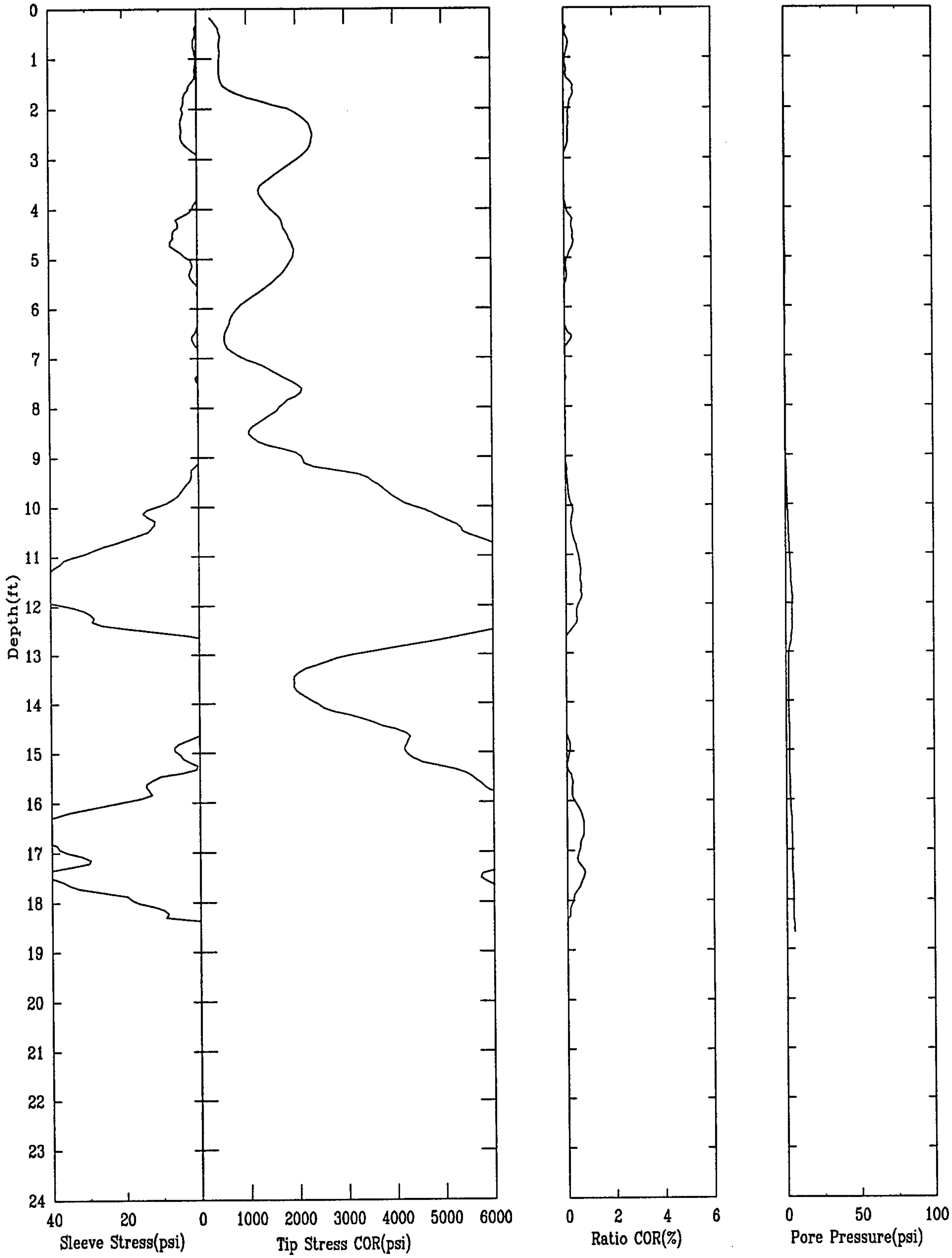

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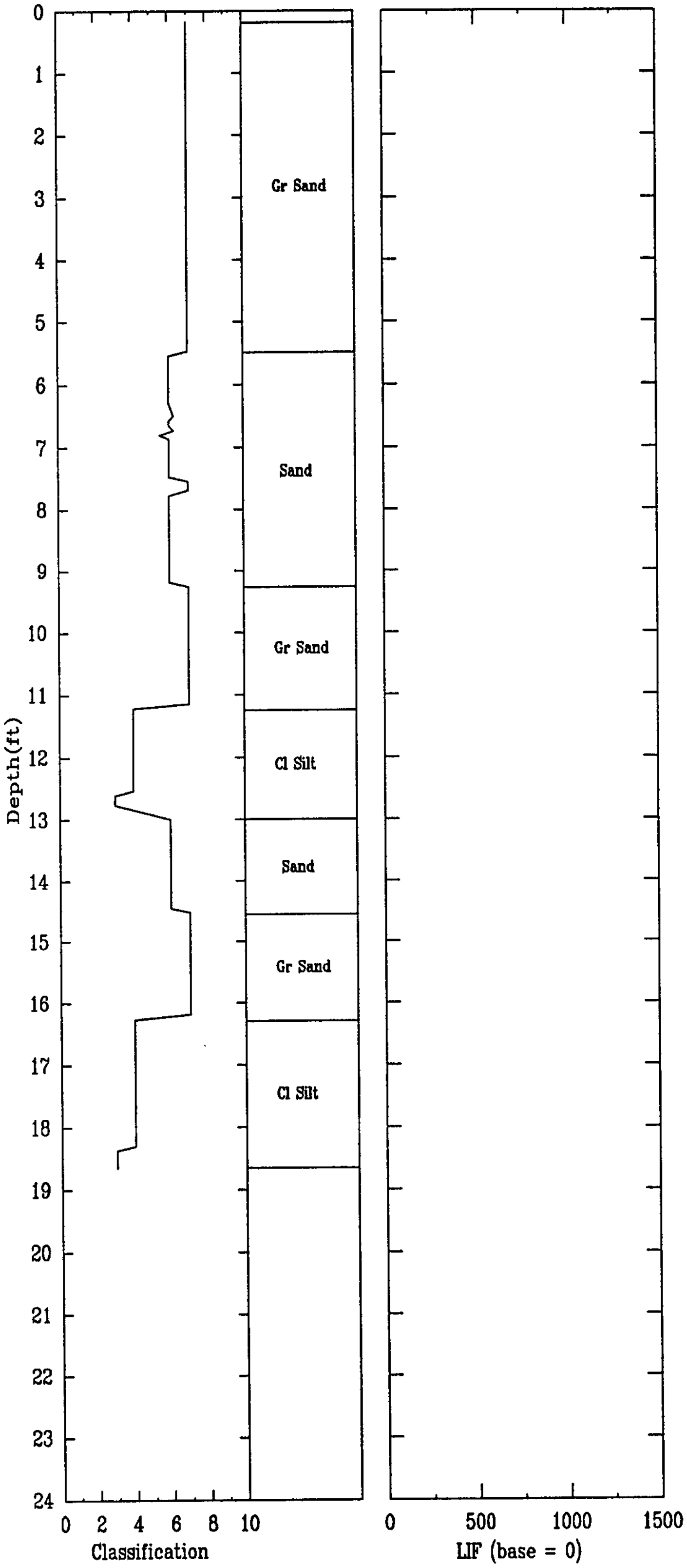

CCAFB-11 APPLIED RESEARCH ASSOCIATES, INC. 03/28/94

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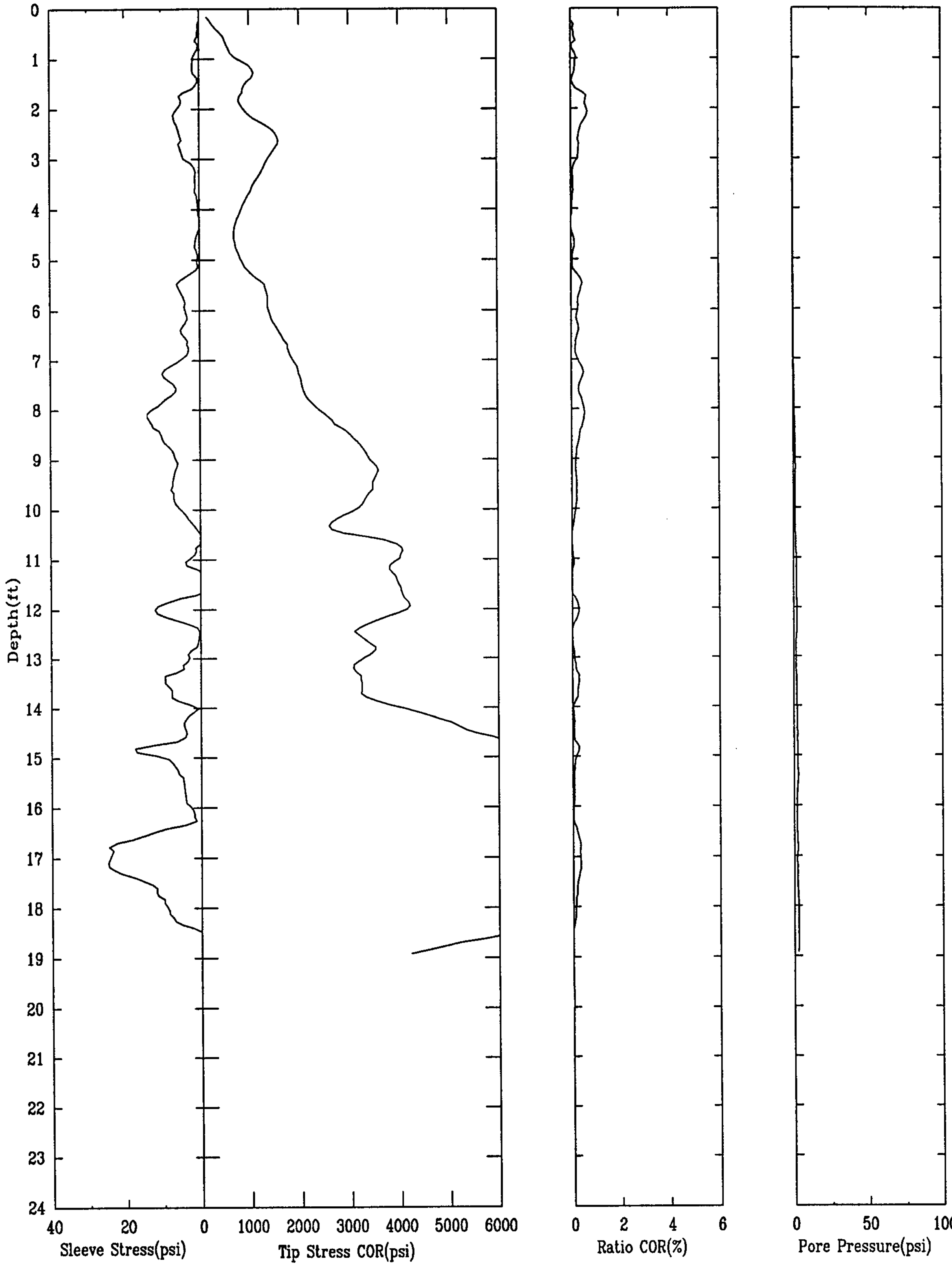

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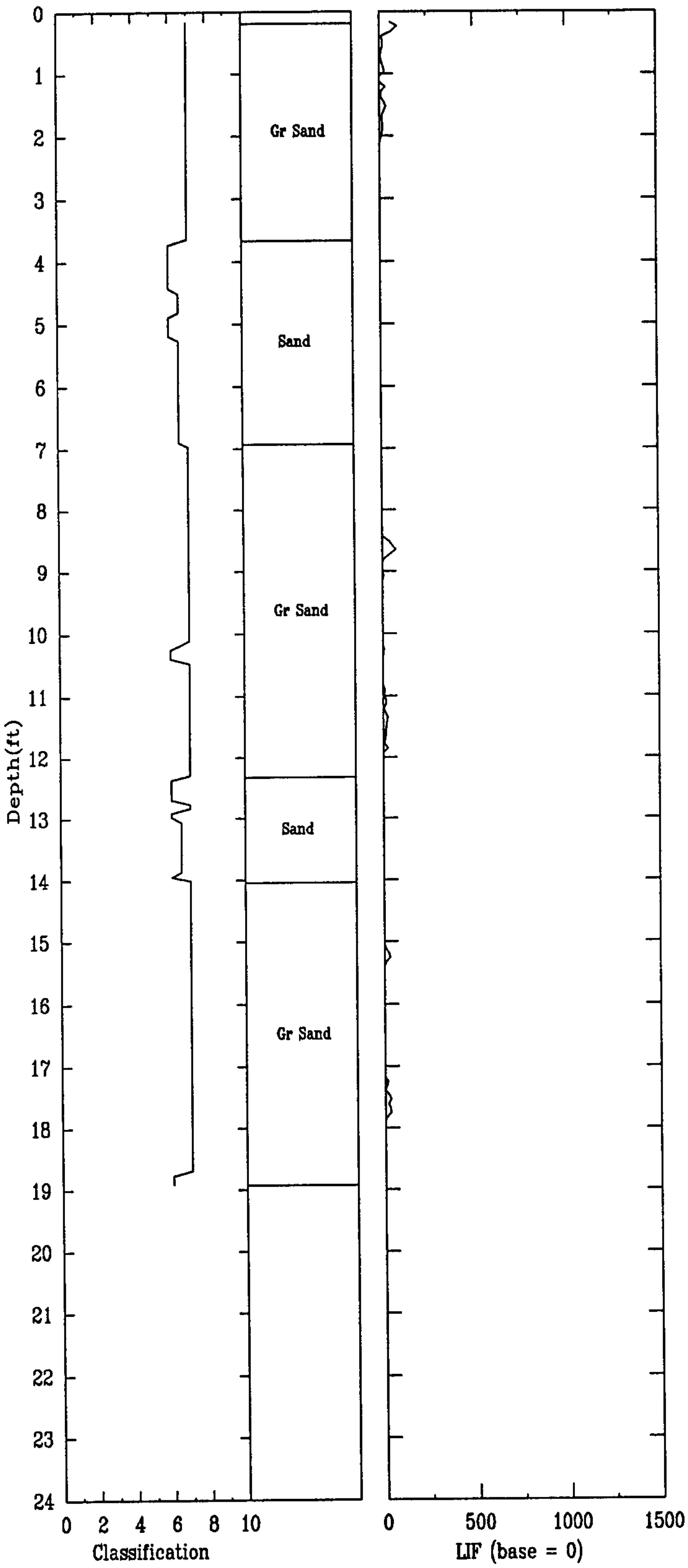
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Gr Sand
Sand
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Sand
Gr Sand
0 2 4 6 8 10
Classification
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LIF (base = 0)